Lessons in

INDUSTRIAL DRAWING

GILMORE
Educational Publishing Company

BALL'S SERIES OF TEXT BOOKS.

LESSONS IN INDUSTRIAL DRAWING

INCLUDING:

FORM-STUDY; PAPER-FOLDING; STICK-LAYING; CONSTRUCTION; REPRESENTATION; DECORATION.

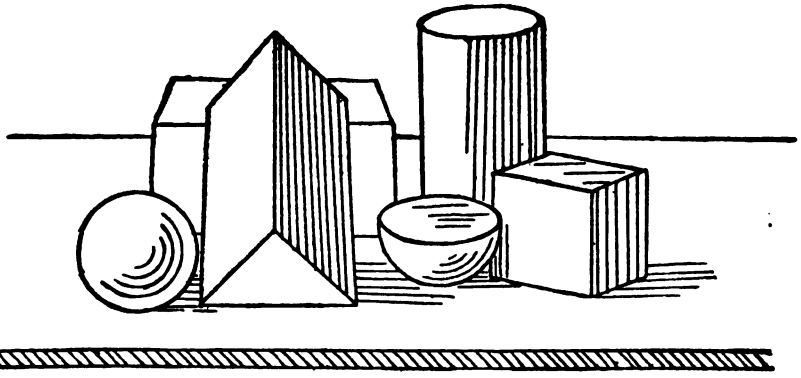
ARRANGED BY

MARY ISABEL GILMORE.

BOSTON:
EDUCATIONAL PUBLISHING COMPANY.
1892.

CONTENTS.

FORM STUDY AND DRAWING.



" Impression must precede Expression "

— DELSARTE.

It is plain that form-study should precede drawing if we consider for a moment, that drawing is simply the expression of our ideas of form.

A thorough study of the type solids — the regular geometric solids that are the basis of industrial drawing — will furnish us with well defined ideas of form.

These solids should be placed in the hands of the children to cultivate their powers of observation, and to enlarge their knowledge of the facts of form, through the sense of touch as well as of sight.

The first primary year is to be spent studying the sphere, cube, cylinder, square prism, hemisphere, and right-angled triangular prism.

They are presented in the order named and studied,

1. *As wholes*,
2. *As to surfaces and faces*,
3. *As to edges*,
4. *As to corners*.

First as Wholes.

Place the solid in the hands of the pupil, (small models should be provided for each one) that he may grasp it, handle it freely, and when practicable model it in clay, so that a complete mental image of the same may be formed.

Ask what part of the object they see and touch? Eliciting the answer "the outside."

Surface is as easily said as outside when the pupil knows that *the outside of any object is called the surface*. When the cube is taken in hand and the fingers passed carefully over it, we find parts of the surface limited, and by questioning develop the terms *edge* and *face*.

Face is a limited part of a surface

An Edge is formed by the meeting of two faces.

This leads to the second step in the order of our study.

Second as to Surfaces and Faces.

By passing the fingers over the surface of the solids, the pupil

discovers a decided difference. He notes a plane or flat surface, a curved surface, and a round surface.

Third as to Edges.

Looking carefully he will find that the faces that come in contact to form the edges, are not all of the same shape, and will learn that edges may be *curved or straight.*

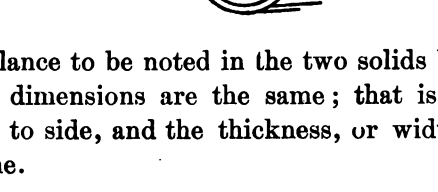
Fourth as to Corners.

The number of corners is to be noted as well as the difference in shape.

After some preliminary study of each it is well to take the sphere and cube together, so that we may learn their resemblances and their differences. (This plan for work is based upon the use of models manfactured for school use in which the proportions are as one to two.)

Explain carefully the meaning of dimension, a term in almost constant use.

Dimension is Extent in One Direction.



The resemblance to be noted in the two solids before us is, that in each case, the dimensions are the same; that is, the height, the width from side to side, and the thickness, or width from front to back are the same.

Considered *as wholes* they have this point of similarity.

Considered *as to surface* we begin to note their differences. The surface of the sphere is curved equally in all its parts, while the surface of cube is composed of six equal plane faces.

When any two of these faces come in contact we find an edge formed, which is the third topic in the study of a solid.

Considered as to *edges*. The cube has twelve edges, the sphere has none.

Considered as to *corners*. Again the sphere has none, since it has no edges to form them; the cube has eight corners, and to form these corners three faces must come in contact. The angles of each of these plane faces are right angles, so twenty-four right angles are to be found on every cube.

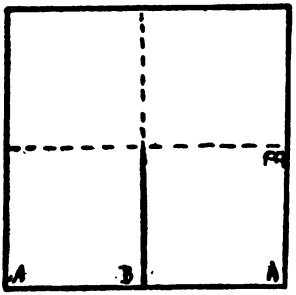
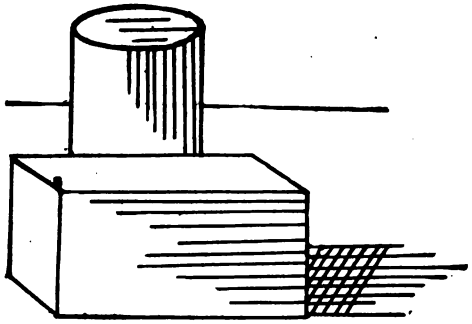


FIG. 1.

To illustrate outside and inside corners, give pupils squares of paper, fold as indicated in Fig. 1, cut a semi-diameter — heavy line (Fig. 1). Fold so that corresponding letters will be over each other,

and hold the fold in place with a drop of mucilage. This simple exercise will be found helpful in giving a definite idea of the position of the faces that make a corner.



Cylinder and Square Prism.

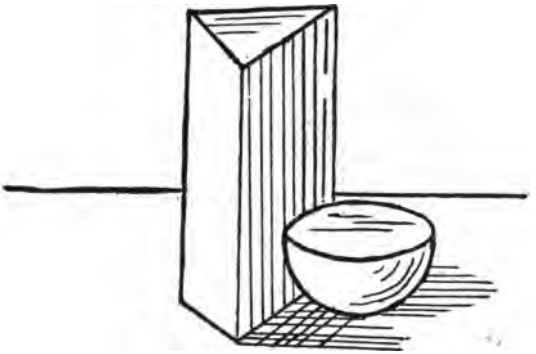
STUDY FIRST AS WHOLES. —What points of resemblance have they?

Answer.— The three dimensions are the same in each

SECOND AS TO SURFACE AND FACES.—The cylinder has both curved and plane surfaces; the square prism has only plane surfaces.

THIRD AS TO EDGES.—The cylinder has curved edges; the square prism straight edges.

FOURTH AS TO CORNERS. The square prism has the same number of corners as the cube. The cylinder has no corners. Compare the cube and square prism. *Question* — Could a square prism be made from cubes? How many would be required?



The right-angled triangular prism and the hemisphere are to be studied in like manner. Compare the sphere and hemisphere showing that if the sphere is divided equally it will make two hemispheres; and that the square prism will make two right-angled triangular prisms.

The type solids are studied in the order named for the reason that the sphere is the simplest; the cube next for the reason that it resembles it, yet at the same time is most unlike it; the cylinder third because it combines the characteristics of both.

Owing to the fact that the sphere and cube have the same measure in the three dimensions, we do not speak of placing them in a vertical or horizontal position, but from the cylinder and prisms having larger measure in one dimension than in the other two, we

can by placing them in different positions and questioning carefully develop the terms vertical and horizontal, always bearing in mind "that technical terms should always *follow*, *not precede* the observation of the form of figure to which they apply."

If it is possible to direct the pupils' attention to the horizon line, so that lines and surfaces may be compared with it, (all that are parallel with it being horizontal and all at right angles with it being vertical), you have the best means of making the terms clearly understood. An excellent authority gives the following arm exercise to illustrate the terms horizontal and vertical.

"Pupils stand erect with arms at sides. Keeping the arms straight raise them until they point to the ceiling; use term *vertical*. Repeat this movement with each arm separately, then together.

Again stand with hands at sides, arms straight. Raise hands level with shoulders. Move arms to the front separately and together, — use term *horizontal*. Repeat these exercises frequently."

Review these terms by asking pupils to indicate the various vertical and horizontal surfaces within the school-room.

When we are studying the faces, "that is limited parts of the surface" of the solids, we note

1. *The character of the faces*,
2. *The shape of the faces*,
3. *The position of the faces*,
4. *The relation of the faces*.

Under "character of faces" teach *round* face of the sphere, the curved and plane of the cylinder, round and plane of the hemisphere, and the plane faces of the cube and prisms.

Under "*shape of faces*" teach the form of the plane geometric figures that are derived from the solid.

Under "*position of faces*" teach whether they are vertical, horizontal, or oblique.

Under "*relation of faces*" teach whether the faces are parallel, perpendicular, or oblique to each other.

Character of faces.

- round . . . . sphere,
- curved and plane . . cylinder,
- round and plane . . hemispere,
- plane . . . . cube and prisms.

Shape of faces.

- Visible part of sphere, top and bottom faces of cylinder, . . circle.
- Faces of cube, top and bottom faces of square prism, . . . square.
- Side faces of the prisms, . . oblong.
- Top and bottom faces of right-angled triangular prism, . . . triangle.

Position of faces.

- All faces of cube and square prism are either vertical or horizontal.
- Triangular prism placed in vertical position has all faces either vertical or horizontal.
- Triangular prism placed horizontally has one face, *oblique*.

Relation of faces.

- Opposite faces of cube and square prism are parallel to each other; adjacent faces in the same solids are perpendicular to each other.
- Top and bottom faces of the triangular prism are perpendicular to the side faces. Two of the side faces are perpendicular to each other; one is oblique to the other two.

Faces are parallel to each other when they extend in the same direction.

Faces are perpendicular when they are at right angles to each other. A square corner would be formed by their intersection.

Faces are oblique to each other when they form angles other than right angles

The solids are considered, first "as wholes," second "as to surfaces and faces," third "as to edges."

An edge is formed by the meeting of two faces.

A profile is the limit of the visible part of a round or curved surface.

Edges also are to be taught as to character, position and relation.

Character of edges.	Curved,	on the cylinder.
	Straight,	on the cube and prisms.
Character of profiles.	Curved,	on the sphere.
	Straight,	on the cylinder.
Position of edges.	Vertical,	
	Horizontal,	
	Oblique.	
Relation of edges.	Parallel,	to each other.
	Perpendicular,	to each other.
	Oblique,	to each other.

Profiles and edges limit and give shape to the faces and parts of faces visible.

Corners or angles are formed by the meeting of two or more edges.

Corners.
- Right angle, all angles of cube and square prism.
- Acute angle, four angles of the triangular prism.
- Obtuse angle may be formed by placing the right-angled triangular prism horizontally upon the square prism.

Every school-room is full of examples of the different corners and angles, and the pupils should point out as many as possible aside from those found on the solids in their hands. Throughout this work teachers should be ever mindful that the work is but begun when we study the solids. "Finding forms of the same general shape as those taken as types, is of the highest importance. Unless this is done pupils are not learning to pass from the particular to the general. They are not taught to see many things through the one, and the impression they gain is that the particular forms observed are the only forms of this kind. Certain things are taught that through them other things may be seen. Teaching is leading pupils to discover the unity of things."

PAPER-FOLDING.

Time and patience must be lavished on form-study, before we are ready for drawing. In the case of older pupils the two may go hand in hand, but with the younger, form study should have the precedence.

Give every possible opportunity for *making* the forms under consideration.

Paper is within reach of all, and by using it for folding, cutting, and pattern making, you add greatly to the child's resources for acquiring form knowledge. The ability to make a required form is of far more value in industrial training, than to make a drawing of the same, however well executed.

To know all about an object we must make it with our own hands, and until we have attempted to do so, we do not realize how superficial our knowledge is of its form and structure. To be able to make a drawing of an object, requires far less accurate conception of its form than to make it, but both are indispensable to the development of the observing powers.

Pupils may be furnished with squares of paper already cut, or given strips of paper from three to four inches in width from which to cut squares, as directed by the teacher.

Place the shorter edge on the longer, fold at the corner, and cut even with the edge folded over — from "a" to "b." (Fig. 1).

Fold the lower edge of a square even with the upper edge. The fold thus made represents the diameter of the square. The child

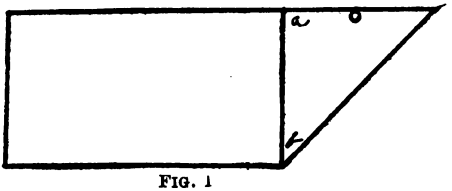
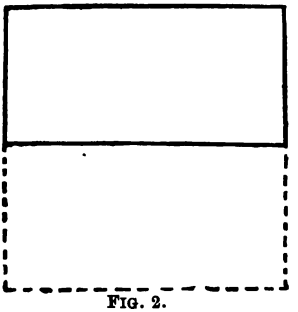


FIG. 1



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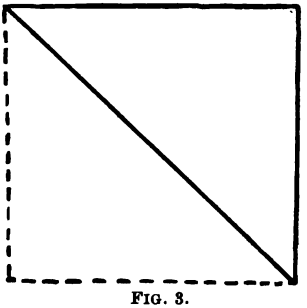

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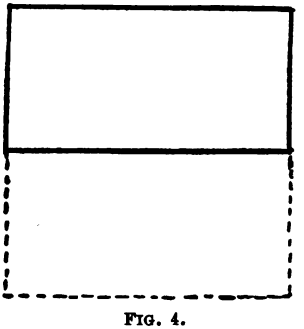

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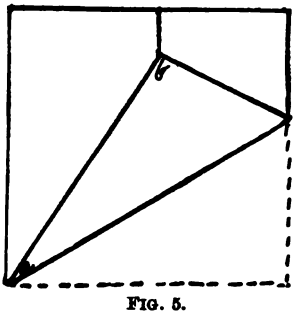

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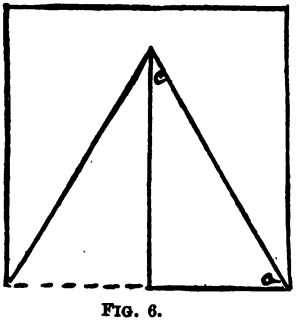
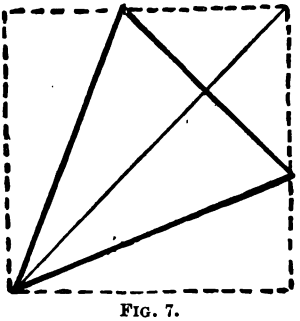


FIG. 6.

readily learns from this the meaning of diameter, and will soon be able to form a definition of his own. The diameter divides the square into two oblongs. (Fig. 2). After a few repetitions of this exercise, the youngest child will recognize the oblong in familiar objects, and the definition will be learned almost unconsciously. By folding both diameters, we divide the square into four small squares. It is well to cut some of the figures that are thus folded, and keep these smaller forms thus made for future use. A profitable exercise is to give these small forms to to the children to place together, so as to form the original figure from which they were cut. This is not to be done until after they have had considerable practice in folding and cutting.

Fold another square from corner to corner (Fig. 3). So teach the term *diagonal;* also that this line divides the square into two right-angled triangles. If the other diagonal is folded, four right-angled triangles will be formed.

The different geometric figures are easily taught from paper foldings. We will take the triangles first. Those named from the sides, equilateral, isosceles and scalene; those named from angles, acute, oblique and right-angled triangles. One side of the square is used as the base of the equilateral triangle. Fold a diameter at right angles to this side (Fig. 4), for the reason that the angles of an equilateral triangle are always to be found in a line that would bisect the opposite side. We know that all the sides of this triangle must be equal, so we fold the lower edge of the square over until one angle just touches the diameter (Fig. 5). Cut even, with the edge folded over from "a" to "b." Then fold again on the diameter as in Fig. 6, and cutting even with the folded edge "c" to "a," you have an equilateral triangle.



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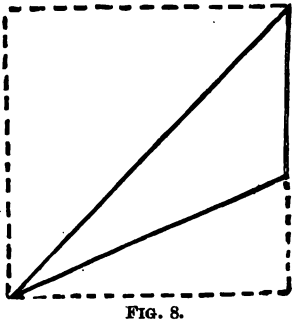


FIG. 8.

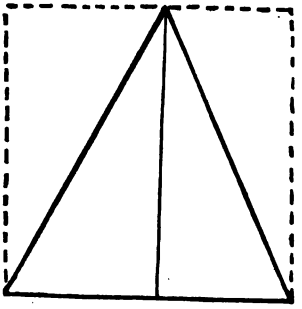
Isosceles Triangle.

Take a square and fold one diagonal. Fold again so that the lower edge of the square will fall on the diagonal. Fold the left edge of the square over so that it will fall on the same diagonal, and just touch the lower edge, as folded over. Fold the upper right-hand corner so that it will fall on the same diagonal, and at such a distance from the center that the fold thus made will connect the other two. Cut the last three folds. Heavy lines in Fig. 7 represent the folds to be cut. After cutting, question carefully as to the number of triangles made from the square, the length of their sides, size of angles, etc. Keep the triangles for use in familiarizing pupils with the different shapes the triangles may assume, and yet fulfil all the requirements of the definition they will learn of each later on. A square folded and cut on a diagonal gives an isosceles triangle, but at the same time it is an example of a right-angled triangle and some confusion of ideas might result. In the first work it is better to make the distinction quite clear between the six triangles. After they are perfectly familiar with the forms, they should be led to think and determine for themselves that three triangles may combine all the requirements of the six.

Scalene Triangle.

Fold one diagonal. Fold the lower edge of the square so that it will fall on the diagonal — crease this fold and cut it, also cut the diagonal. (Fig. 8). Question as to the triangles that result from cutting this scalene triangle from the square.

Right-angled triangle is taught by cutting the diagonals of the square.



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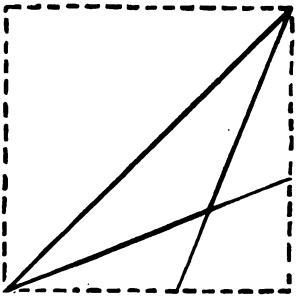

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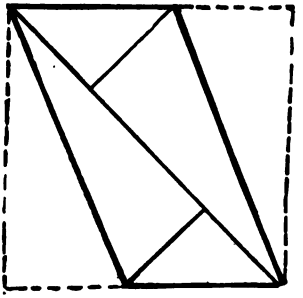


FIG. 11.

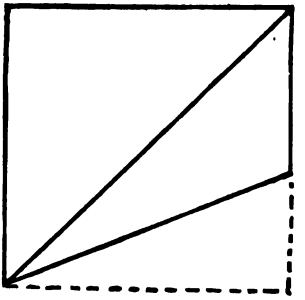


FIG. 12.

Acute-Angled Triangle.

Fold diameter at right angle to the lower edge of the square. Fold from upper end of the diameter to each of the lower angles, as in Fig. 9.

Obtuse-Angle Triangle.

Fold one diagonal of the square. Fold the lower edge over until it falls upon the diagonal, also the right edge until it touches the same line. Cut the diagonal and the two folds to their point of intersection as in Fig. 10.

The six quadrilateral may also be taught by folding and cutting.

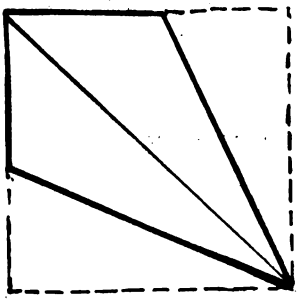
We have learned to fold and cut the square, also that if we fold the squares so that opposite edges coincide we will have an oblong or parallelogram.

Rhomboid.

Take a square, fold a diagonal, then fold the left edge of the square so that it will coincide with the diagonal. Then fold the right edge to coincide with the diagonal. Cut the last two folds as indicated by heavy lines. (Fig. 11).

Trapezoid.

Fold one diagonal of the square, then the lower edge so that it will fall on the diagonal. Result — trapezoid — a plain figure having only two sides parallel. (Fig. 12).



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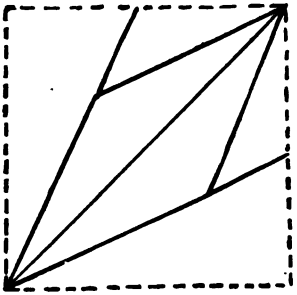


FIG. 14.

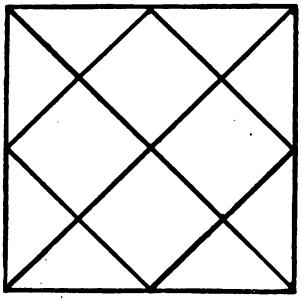


FIG. 15.

Trapezium.

Fold a square and one diagonal. Fold so that the lower edge of the paper will coincide with the diagonal. Fold again so that the right edge will be on the diagonal. Cut the last two folds and you have a trapezium as indicated by the dark lines. (Fig. 13).

Rhombus.

Fold square same as for trapezium. Then fold the shorter sides of the trapezium over until they coincide with the diagonal. Cut the folds indicated by the heavy lines in Fig. 14.

Give each pupil a square. First fold the diagonals, then fold each point to the center. Then open the paper and question as to how many of the figures already folded are to be found outlined by the creases in the square folded as Fig. 15.

When pupils have made the triangles and quadrilaterals they should be taught to describe each in the most concise language; to note what points they have in common, and what are their differences.

The trapezium and trapezoid may differ greatly from those cut according to the directions here given, and yet fulfil all requirements. After pupils are familiar with the facts, that the trapezoid has two sides parallel, and that the trapezium has none of its sides parallel, let them cut as many different ones as possible. Collect these and keep with other quadrilaterals and triangles that have been cut. Let one pupil describe any of these figures that he wishes; send another to select it, guided only by the description given.

Example.— Find a figure having four equal sides, and no right angles; — rhombus.

"Pupils should be encouraged to cut and measure, and to draw

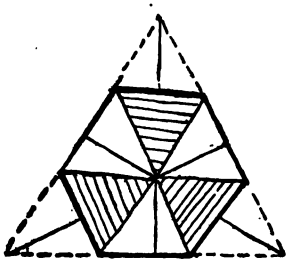


FIG. 16.

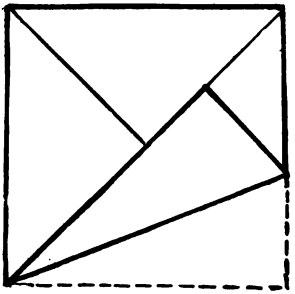
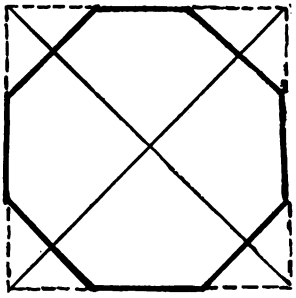


FIG. 17.



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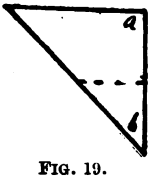
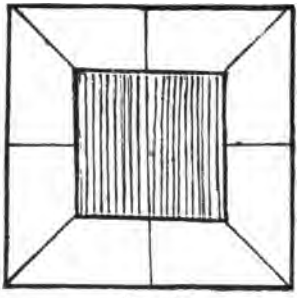


FIG. 19.



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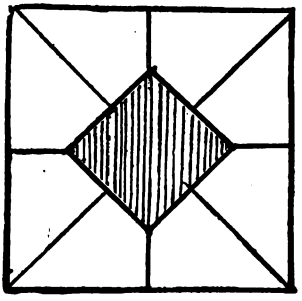


FIG. 21.

and measure many squares, for the practice trains both eye and hand. These exercises may seem very simple, but neither a boy of five nor a man of fifty can cut or draw a four-inch square who has not been trained to observe."

More accurate knowledge of form of circle, hexagon, and octagon, and familiarity with the use of the terms bisect, trisect and quadrisect may be gained from the following exercises:

To Fold a Regular Hexagon.

Cut an equilateral triangle. Fold adjacent sides together, and the crease thus made will bisect the side opposite. The place where the folds intersect is the center of the triangle. Fold each corner over until it touches the center as in Fig. 16. Folding the hexagon in this way shows very clearly that six equilateral triangles make the regular hexagon, and this knowledge will be of great practical value in later work, before pupils can be taught to draw this form by problem and mechanical aids.

To Fold a Regular Octagon.

Fold the diagonals of the square. Fold from each corner as in Fig. 17, marking the length of a semi-diagonal on each of the adjacent sides. Fold from point to point and cut as indicated by the heavier lines in Fig. 18.

Bisect.— To divide into two equal parts.

Trisect.— To divide into three equal parts.

Quadrisect.— To divide into four equal parts.

Fold a square three times, first the diagonals, then the diameter (Fig. 19). Bisect the last fold, "a — b", and cut at right angles as

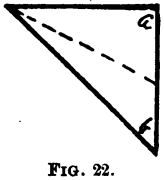


FIG. 22.

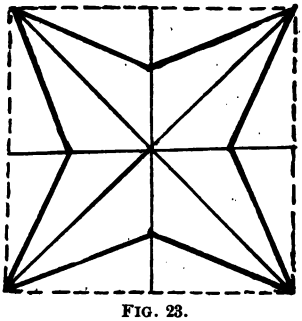


FIG. 23.

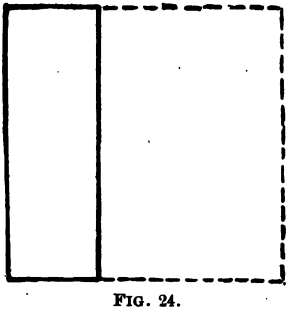


FIG. 24.

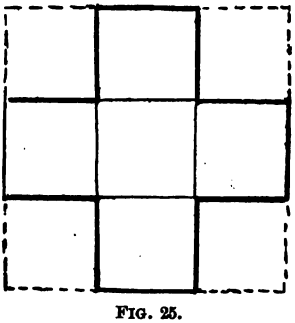


FIG. 25.

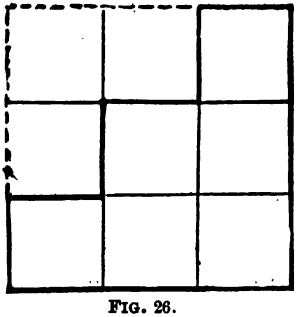


FIG. 26.

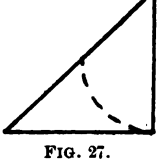


FIG. 27.

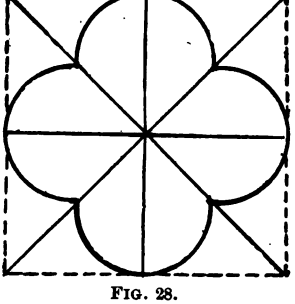


FIG. 28.

shown by dotted lines. Result — a square within a square on its diameter (Fig. 20).

Again, fold three times same as Fig. 19. Bisect the longer edge and cut at right angles. Result — a square on its diagonals within a square on its diameters (Fig. 21).

If colored paper is used for this work, it is well to paste a contrasting color, or one of neutral tint back of the spaces made by removing the squares in the center.

Fold square three times diameter last. Bisect last fold, and cut to the corners as indicated by the dotted lines in Fig. 22. Open the paper and you have the four-pointed star — heavy lines in Fig. 23.

Square folded to trisect sides shown (Fig. 24).

Trisect each side of the square, cut out the corner squares.

Result — *Greek cross* (Fig. 25).

Trisect each side of the square. Fold; cut out three squares in the upper left-hand corner. Result — end view of a flight of steps. (Fig. 26).

Fold a square on its diameters first then on its diagonal. Bisect the diagonal, or longer edge, and sketch a quadrant from that point to the end of the diameter — cut as indicated by dotted line in Fig. 27. (Result, Fig. 28). Quatrefoil, used in ecclesiastical art as the symbol of the four Evangelists.

Quadrisect the sides of the square — Fold — dividing the square into sixteen small squares. Next fold the diagonals. Place points bisecting the diagonals of the four central squares. Cut from the outer points of quadrisection on the sides of the square to the nearest point on the diagonal, — as indicated by the heavier lines in Fig. 29. Result — Maltese Cross.

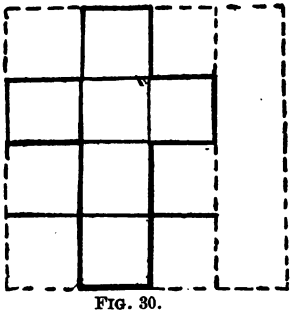


FIG. 30.

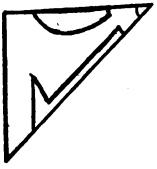


FIG. 31.

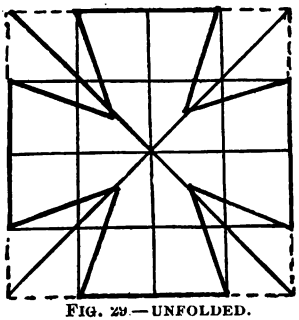


FIG. 29.—UNFOLDED.

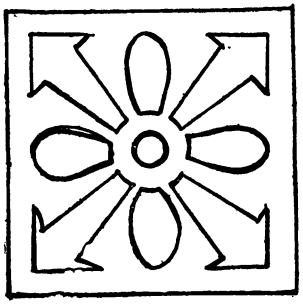


FIG. 31.—UNFOLDED.

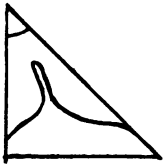


FIG. 32.

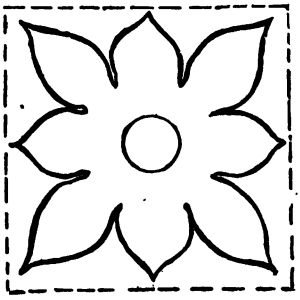


FIG. 32.—UNFOLDED.

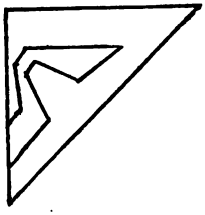


FIG. 33.

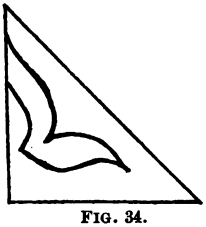


FIG. 34.

FIGS. 33 AND 34 UNFOLDED.

Quadrisect the horizontal sides of the square and fold. Cut off the outer quarter indicated by dotted lines (Fig. 30). Quadrisect the vertical sides and fold. Cut out the upper corner squares and the lower corner squares with the ones next above. Result — Latin Cross. (Fig. 30).

When pupils are quite familiar with the use of the terms diagonal, diameter, bisect, trisect, etc., and with the results obtained by folding and cutting, let them try to produce some original ornamental forms by folding squares or triangles and sketching a few simple lines as guides. Suggestions for this work are given in Figs. 31 to 34.

These may be placed so as to form borders, and in later work will be found useful in illustrating elementary design.

If colored paper is used for this work, it should be carefully selected, so that the color sense may be cultivated in connection with form study.

When sufficient skill is attained to cut the forms accurately, the best may be selected, and mounted on large sheets of paper (20 x 24 inches) of a neutral tint, for the decoration of the schoolroom and also to keep the subject of form constantly before the pupils.

STICK-LAYING.

Stick-laying is another excellent help in form-study. The splints or "lamp lighters" are easily obtained, inexpensive, and will be found useful in number work as well as form-study.

The sticks should be prepared for school-room work by cutting them into different lengths by accurate measurement, so that by their constant use the child may begin to acquire the knowledge of exact dimension that will be of such inestimable value to him throughout his life. Cut the sticks in one, two, three, four, five, six and eight-inch pieces, making a greater number of two and three-inch lengths than of the other dimensions.

These sticks may be used with great advantage in explaining the relative positions of straight lines.

Straight lines may extend
1. In the same direction, that is, be parallel.
2. In different directions, that is, form an angle.

The angle may be explained by holding the sticks in contact at the ends and diverging It is difficult to make a child comprehend that an angle is the divergence of two lines rather than the surface between them, but if with two sticks held as above, the statement is made that the angle is the "opening" between the lines, and at the same time the sticks are made to open and close — thus conveying a practical idea of the "opening," as distinct from a surface, a much clearer idea of the angle is presented to the mind of the child than can be done with lines on a surface. An angle is simply

the difference in direction. Not merely of lines and surfaces, but any difference in direction. *Example.*—Two persons walking in diverging or converging directions proceed at an angle.

Another point to be carefully *noted.* It is not necessary that the lines intersect to indicate this difference of direction — or angle, nothing is added to the difference by their intersection, it is only necessary that they intersect when we wish to measure the angle, or to make another equal to it.

The importance of fixing right ideas of the relation of lines cannot be too strongly urged.

With the sticks we can represent the shape of faces of the straight-edged solids. Then with other sticks indicate the diameters and diagonals. When studying the cube and prisms, use the sticks to represent all the faces connected as they may be shown on a flat surface.

Place a cube on the desk and turn slowly, counting each face as it comes in view. Four squares of the same size, placed edge to edge will be noted by the pupils. Let them represent these four squares with the sticks as in Fig. 1.

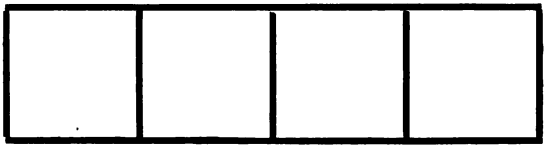


FIG. 1.

We have learned that the cube has six equal faces. We have counted and made a representation of four of these. Where do we see the other two? The cube rests upon one face, the edge of which joins the lower edge of one of the four squares just made, and the top face touches the upper edge of this square. Make two more squares

to represent these faces, one on the upper, the other on the lower side of the four-connected squares as in Fig. 2.

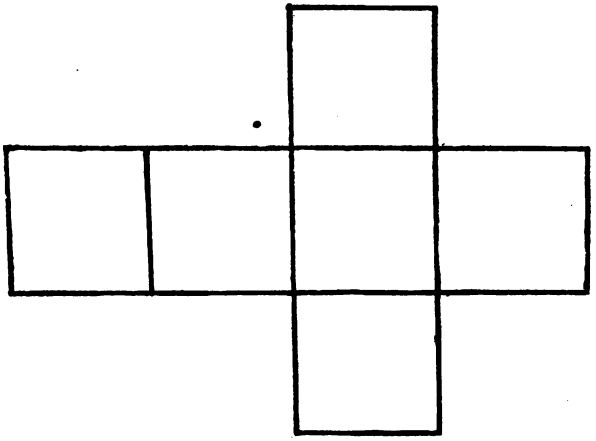


FIG. 2.

Each step should be explained carefully. A drawing on the board, the size of the large cube used, might make it clearer. Turn the cube over and over on the horizontal squares, then turn so as to cover the ones above and below, show that the squares in the drawing are identical in form and position with the faces of the cube.

This is the simplest form of "pattern making," and helps to develop a well defined idea of the surfaces of the solids, before the child is capable of expressing the same by drawing.

The surfaces of the cube and prisms are all that can be illustrated in this way in the first year work.

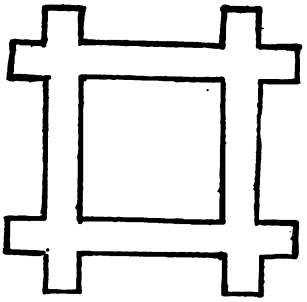


FIG. 3.

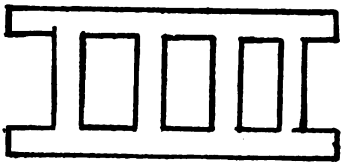


FIG. 4.

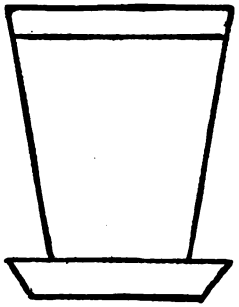


FIG. 5.

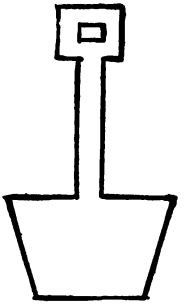


FIG. 6.

Encourage pupils to observe the form of common objects, and try to represent the outline with sticks. *Examples.*— Figs. 3, 4, 5, 6, 7.

Stick-laying may be used profitably in connection with paper-folding. An exercise given one day in paper-folding may be reproduced the next day, or several days after, by using the sticks to represent the edges and creases of the previous work.

The element of time intervening, and the effort to recall the form and reproduce it, aid materially in fixing definitely the form idea. Nearly all the exercises under paper-folding may be used in

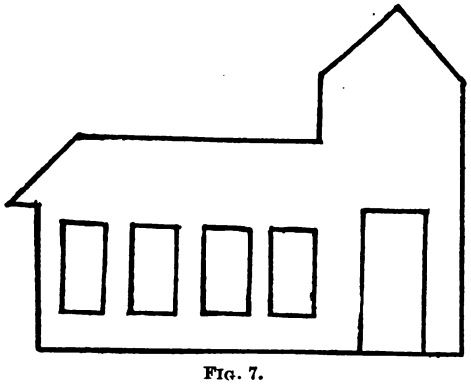


FIG. 7.

this way. Simple borders may be formed with the sticks, reviewing instruction in the direction of lines — angles. This work should be done at the dictation of the teacher, afterward reproduced by drawing on slates or black-board.

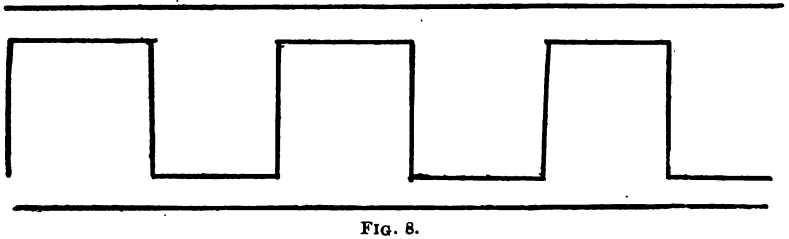


FIG. 8.

Dictation for Figure 8.

Place two of the longest sticks horizontally three inches apart. Near the left end of these place one of the two-inch sticks vertically, with its ends equally distant from the horizontals. At the upper end of the vertical stick place another of the same length at right angles to it. Place another vertically touching the right end of the horizontal, and so on, continuing the length of the horizontal sticks placed as border lines.

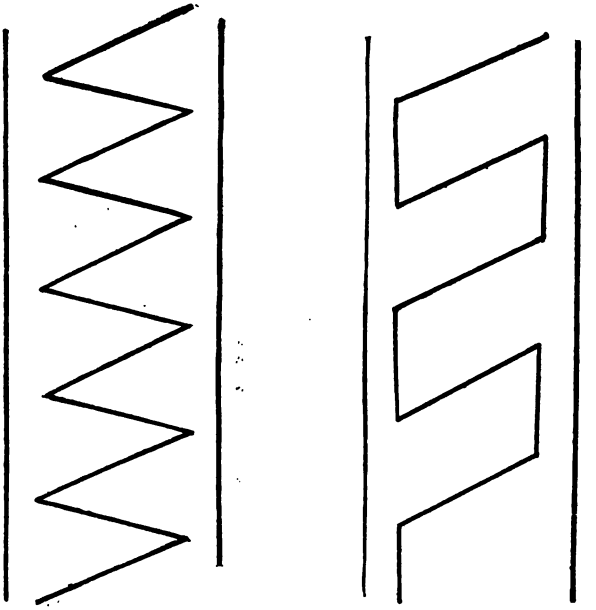


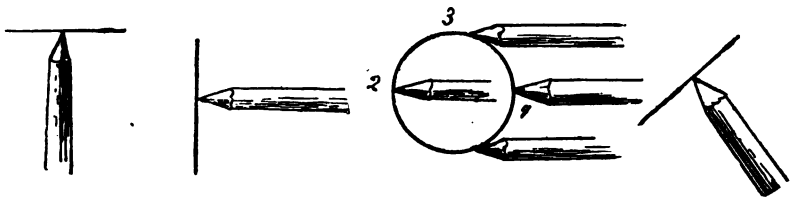
FIG. 9. FIG. 10.

Dictation for Figures 9 and 10.

Place two of the longest sticks vertically three inches apart, and between arrange a border with short sticks, all the angles of which must be oblique — *i. e.*, acute or obtuse.

Simple geometric figures may be drawn on the black-board to be copied as closely as possible with the sticks. These suggestions are to give variety to the work, and to awaken that interest which will lead to close observation, that being the basis for all thorough work in drawing.

The attention has been thus far directed toward form-study, which should always precede drawing with primary pupils; but little drawing, and that on slates and black-board should be required during the first two years of school work.



DRAWING.

" The pencil speaks the tongue of every land."

— DRYDEN.

Drawing is the graphic expression of form. Some one has said "that drawing is the short-hand language of modern science." Careful drawings are to technically educated people what pictures are to children. One fact should be always borne in mind, that good drawing is not copying; it should rather be the expression in visible form of something which is in the person's mind. Having devoted time and thought to form-study, we must turn our attention to the attainment of the skill and dexterity of hand necessary to clearly express our ideas.

"Pupils should not be hampered at the outset with many rules, but should be led gradually into proper sitting positions and proper ways of holding the pencil." All should be provided with long pencils whether lead or slate. Pencils should have a *round*, never a sharp pont. To gain the attention of the class it is well to have certain positions assumed at given signals. At the beginning of the exercise the pencils and paper should be placed on the desk, the long edge of the paper parallel with the long edge of the desk. During the time given to instruction preparatory to work, pupils should sit erect, well back in the seats, hands in laps.

When the signal is given for drawing they should bend forward slightly, still sitting well back in the seats.

Most pupils bend over too much. Bend only so far as is necessary to see the lines clearly. Much attention must be given to this matter, for free-arm movement cannot be attained by pupils bending closely over the desk.

Position for Drawing Vertical Lines.

Place the right arm on the desk, pencil held lightly, pointing to the left. Pencil should be held about three inches from the point or far enough to reach across the fingers of the left hand. The latter rule is better to use in a class of young pupils.

The left hand rests on the wrist and ends of the fingers in a natural position. Vertical lines are drawn from the upper point downwards, never from the lower to the upper end of the line.

Position for Horizontal Lines.

The body is turned very slightly, with the left side towards the desk, letting the left fore-arm lie parallel with the long edge of the desk. The right hand rests on the desk with fore-arm at right angles to its long edge. Lines should always be drawn from left to right, with the hand resting on little finger.

Position for Oblique Lines.

The position of the body and arm vary slightly for oblique lines, according to their position, always remembering that the pencil must be kept as nearly as possible at right angles to the line to be drawn.

Position for Circle and Ellipse.

For circle or vertical ellipse take the same position as for vertical line. Beginning at the lower end of an imaginary vertical diameter move toward the left and so around to the starting point, always keeping the pencil pointed to the left.

For horizontal ellipse, take same position as for horizontal line, and starting at the top of the short diameter move to the left making a continuous line around to the point of beginning.

Pupils should have much practice in arm movement before touching pencil to paper.

Arm Movement.

Give direction for taking proper position; with pencil held lightly, just above the surface of the desk, move the arm round and round, as though drawing the circle or ellipse, but without the pencil touching the desk. Let the movement be slow so that the eye can follow the pencil — no faster than when actually drawing the lines. Movement for vertical and horizontal lines may be given in the same way. When a free-arm movement is acquired, just touch the pencil to slate or paper and follow same directions. These first lines must be very light and easy to erase, for it is not probable that success will crown the first effort. Let these first sketching lines remain, so that the same errors may be avoided next time. Make another attempt, several if necessary. When the line is finally in a satisfactory position, erase all the incorrect lines, and "Line in" the one remaining.

To "line in" is to make a finished line of uniform width and of even gray tint. To do this, hold the pencil a little nearer the point than for sketching.

Soft Pencils.

The teacher must insist upon the use of the soft pencils, otherwise lines will be made that are impossible to erase. Complaints will be frequent that too black lines result from the soft pencils. This comes from improper handling, too much muscular force is expended. If the pencil is held lightly, supported by the middle finger and held by the thumb and forefinger, just allowed to touch the paper, a gray line will result however soft the pencil. A medium pencil, letter M is best for school work, should be kept for drawing only, and when worn away should be lengthened by a pencil holder.

SUGGESTIONS.

What is free-hand drawing? *Answer.*— Drawing without the aid of instruments. Drawing on the board is the most perfect illustration of the term "free-hand" drawing; and, unless the hand be quite free in its motion and the arm *as well*, fine subtile curves are impossible. Pupils should have frequent black-board exercises, that they may attain the freedom of movement to be gained only by large scale work. An eminent authority says: "The child should begin by learning to reproduce lines, and arrangements of lines on the largest scale possible to his youthful arm."

Care must be taken that the pupil does not try to place his drawing on the board at an inconvenient height. "The top of the drawing should not be much above the draughtsman's head, for above the head the hand will lose its power; nor the lower part below the

level of the elbow when the arm hangs at the side, for to draw then brings the head close to the board and prevents a clear view.

The left side of a figure should always be drawn first; so that when drawing the balancing form on the right side, the eye can take in, not only the part in process, but that already made, to which it is to be symmetrical.

Any of the exercises recommended may be carried out in black-board work, and it is well to have a certain number work at the board during each recitation, so that all may share the benefits of this most excellent practice.

What movement ought to receive attention at every exercise? *Answer.*—Whole-arm movement from the shoulder. Lines should be drawn with a continuous movement from end to end.

Teachers should see to it that horizontal and vertical lines be drawn the entire length without lifting the pencil; in like manner in the circle and ellipse the pencil should be carried from the starting point around to it again.

Give frequent exercises in drawing lines as long as the paper or slates will admit. Place points on line with each other at given distances from the edge of slate or paper (half an inch is enough margin to leave) and connect these points without lifting the pencil. Then divide these lines into two, three or four equal parts by placing points. Or have lines drawn of given lengths. This gives practice in estimating exact distances, while at the same time cultivating free-arm movement. *Rulers* should not be used except to test the accuracy of work after it is completed. Unless the class is large the teacher had better test the work. Beginners will be unable to divide lines accurately, therefore, before proceeding to the more important parts of an exercise, the accuracy of the proportions should be tested and faults corrected. To allow errors in the first

steps, to make all subsequent work "out of drawing" is a great mistake. The eye will not be trained into truthful perceptions by allowing it to grow accustomed to errors; but it will be educated by the substitution of right for wrong every time the wrong is committed.

Position.
Pencil-holding.
Arm-movement.
Character of lines.

} Should receive the most careful attention during every hour devoted to drawing.

The placing of the drawing is an important matter. There should be a margin surrounding the drawing of as nearly equal width as possible. If there is to be any difference it is best to leave extra width above the drawing. If the design, sketch, or whatever form the drawing may take, be square and the paper square, place it in the center. If the paper be oblong and the drawing square or nearly so, make the spaces on either side equal, unless the paper is wide enough to admit another drawing; in that case make the first near the left edge, but always a margin between. If the sketch is longer than wide and the paper of similar form, place the long dimensions of the two parallel. This may seem a very simple matter but attention to these details adds greatly to the appearance of the work when completed, and it gives also an opportunity to cultivate the eye in regard to balance and proportion.

INDUSTRIAL DRAWING.

Industrial drawing is divided into three distinct departments.

CONSTRUCTION.

REPRESENTATION.

DECORATION.

Construction is the science and art of making drawings from which objects may be constructed. It deals with the facts of form, and shows the use that is made of the drawing of these facts in the industrial world.

A *working-drawing* is one from which an object may be constructed. They are necessary to guide the workman in nearly every branch of industry. A working-drawing is made of two or more geometric views of the object.

A *geometric drawing* shows an object in its simplest form,—that is, having length and width, or showing but one face of the object. This, of course, can be represented on a flat surface by one drawing; then another must be made to represent the face showing the thickness of the solid, and so on, until as many views have been made as there are dissimilar faces.

The real shape of the surface cannot always be shown in these drawings, but simply the contour or outline, when the surface is curved or oblique. The real shape, however, is readily understood by the position of the separate views and the lines connecting them.

When we know that certain angles and edges come in contact, we cannot fail to understand the form that will result.

Certain conventional lines are used in working-drawings, and a knowledge of their use is essential.

A ..... B
C —— . —— . —— . —— . —— . —— D
E — — — — — — — — — — — — F
G ———————————————————— H

Dot and Dash Lines, C D, are used to place the drawing — or as centre lines.

Dotted Lines, A B, connect parts of the different views that are in contact in the object.

Dash Lines, E F, represent invisible edges.

Full Lines, G H, represent visible edges of surfaces.

In making working-drawings the top view is always placed either over or under the front view, with corresponding points opposite; the distance apart the views are to be placed is regulated by the space the drawing is to occupy. When more than two views are necessary, the side views are placed in line with the front or upright, with corresponding points exactly opposite.

With older pupils *construction* forms the foundation of their form-study, and great care should be taken that clear ideas be formed of the faces of each solid and their relation to each other.

Young pupils should simply draw the faces of the solids, and place them in proper position that is, over or under, or at the side, but should make no use of the conventional lines.

All may profitably use "pattern-making" which comes under construction. Young pupils may have their first lessons as shown

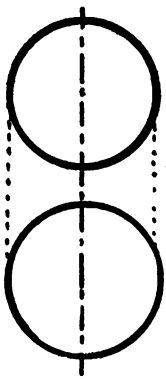


FIG. 1.

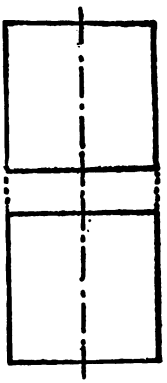
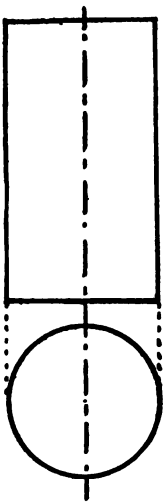


FIG. 2.



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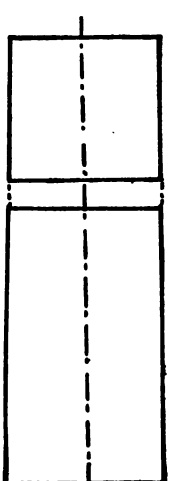


FIG. 4.

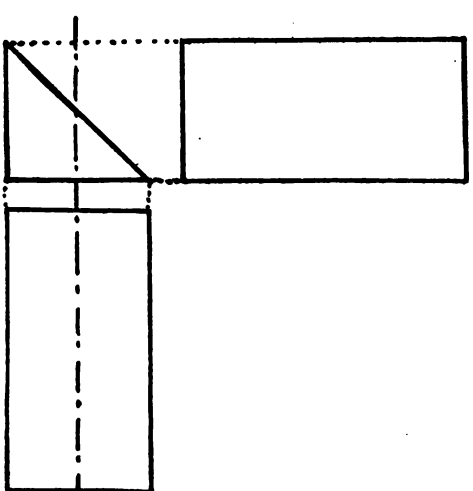


FIG. 5.

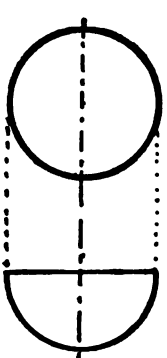


FIG. 6.

in "Stick-Laying," or by placing tablets in position to represent the faces of the solid. Or the teacher may fold light paper around the solid and crease on the edges. Then lay flat again and cut off all parts except those included between the creases. Fold again and hold the edges in place showing a perfect model of the solid.

Figure 1. Working-drawing of sphere.
Figure 2. Working-drawing of cube.
Figure 3. Working-drawing of cylinder.
Figure 4. Working-drawing of square prism.
Figure 5. Working-drawing of right-angled triangular prism.
Figure 6. Working-drawing of hemisphere.

PATERN-MAKING.

Where patterns are to be cut and glued, to be used afterwards as models for drawing, it is best to make them of stout manilla paper called "tag-board," about the thickness of a postal card. For

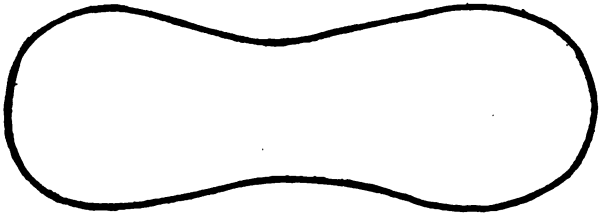


FIG. 8.

work with younger pupils, when it is simply to add to their knowledge of form, colored paper of much lighter quality may be used with good results. Rulers must be used both for making the lines

and creasing the folds. The work must be *exact* in every respect if perfect models are to be formed.

For the sphere and hemisphere some softer material must of course be used. It is a good plan to have pupils draw the pattern of the sphere, and at home make a cover for a ball from it. (Fig. 8).

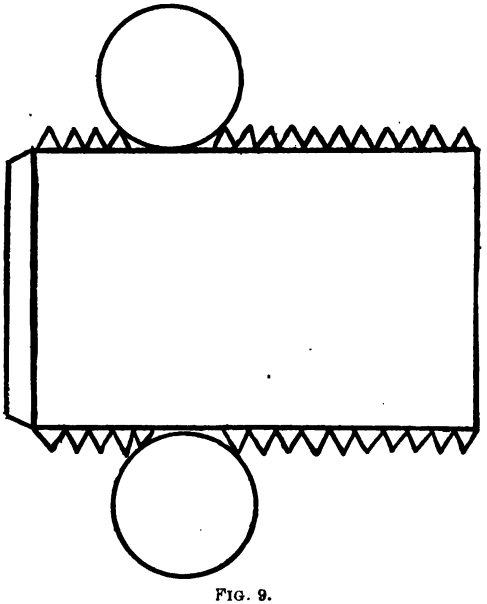


FIG. 9.

The cylinder is easily made by taking any oblong piece of paper and folding each of the long edges over about a quarter of an inch, before the ends are glued together. Cut these edges at short intervals so that they will fit nicely under the circles that form the ends. Try to keep it perfectly round. Glue the cut edges and press down on a piece of paper. When dry cut off the paper even with the edge of the cylinder.

Older pupils who have learned the relative length of the circumference to the diameter of a circle, (circumference is 3.1416 times the diameter,) should make the cylinder of a required size, the height to be given and the diameter of the ends, construct according to diagram given. (Fig. 9). Patterns for other solids are given in Figs. 7, 8, 9, 10, 11, 13, 14. Boxes of various shapes may also be made. (*Example*, Fig. 12).

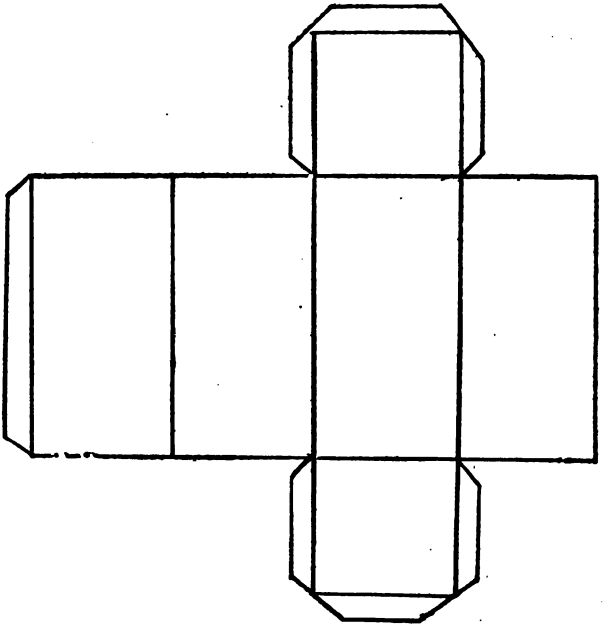


FIG. 7.

In this, as in all other exercises suggested in connection with form-study, the work should not stop with the type solids, but familiar objects of the same general shape should be brought into class, and whenever possible, patterns of these made by the pupils.

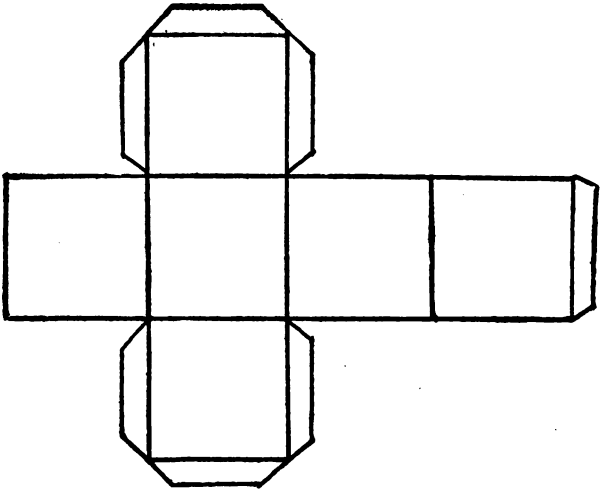


FIG. 10.

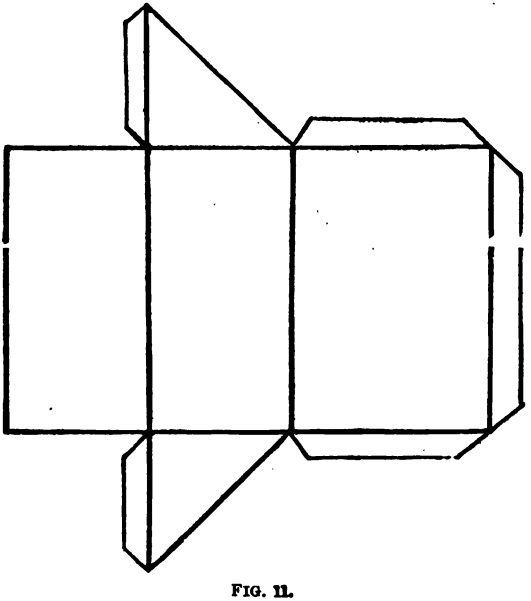


FIG. 11.

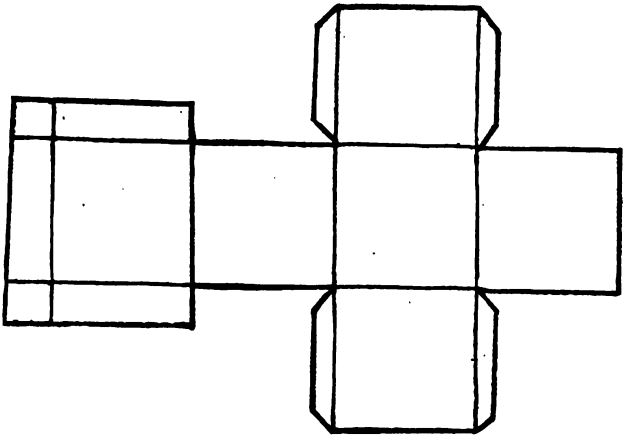


FIG. 12.

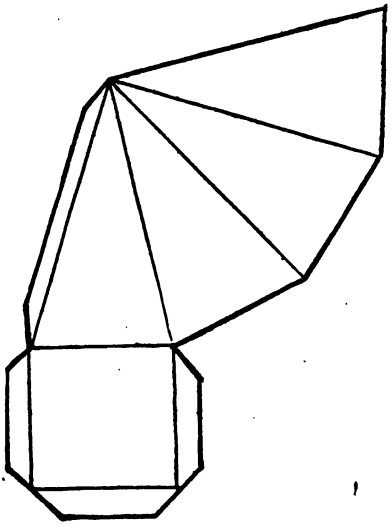


FIG 13.

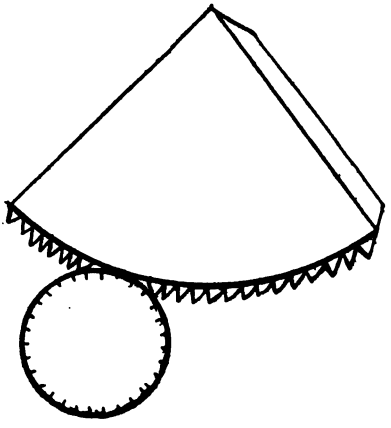


FIG. 14.

REPRESENTATION.

Representation is the art of delineating on a plane surface objects as they appear to the eye when affected by distance and position.

The appearance of an object depends:
1. On its position in regard to the observer.
2. On its distance from the observer.

POSITION affects the apparent *shape* of an object.

DISTANCE affects the apparent *size* of an object.

Pupils should study these changes in appearance from the objects themselves, and if possible discover from their own observation some of the principles of perspective.

Place two objects of the same shape and size at a given distance apart, on a desk or table, then have pupil take position at an equal distance from the nearer object. Give time to observe carefully and see if he can form the right conclusion, that the nearer object appears twice as large as the farther one. Change the distance between the objects and at the same time the distance of the pupil from the nearer one, to test his ability to detect the proportion of the diminution in size; that is, at twice the distance the object appears one-half as high, at four times, one-fourth, etc. It is better to have the objects so placed that their top edges are on a level with the eye of the observer. He will then see that the change takes place in the apparent position of the lower edge of the farther

object, and so from the very first will learn that lines retreating from the eye tend toward its level.

Give many tests of the change in size in proportion to the distance, before attempting to represent the objects by drawing.

To illustrate in another way:

Take a small square of glass and look through it at some large object at a given distance, noting the space occupied on the glass. Change your position to twice the distance, then three and four times, noting on the glass the change in size, until the mind becomes perfectly familiar with the principle that objects diminish in size in proportion to their distance from the observer.

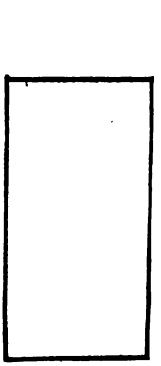


FIG. 1.

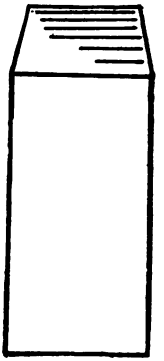


FIG. 2.

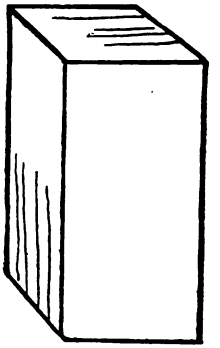


FIG. 3.

The apparent form of every object, except a perfect sphere, varies with every change of position. A square prism held directly opposite the eye so that but one face can be seen, appears to be an oblong. (Fig. 1). Lower it a little, but still keeping it directly in front of the observer, and two faces appear as in Fig. 2. Keeping it at the same level, but at the right of the observer, it appears as Fig. 3.

FORESHORTENED is the term applied to the apparent change in the shape of an object when viewed obliquely; and the more obliquely the object is seen the greater will be the change in shape. We know that the top face of a square prism is a *square*, but when it is below the eye it does not so appear but becomes changed as in Figs. 2 or 3.

A circle seen obliquely always appears an ellipse, narrow or wide according to the angle at which we see it. The representation of objects foreshortened is termed *perspective*.

LINEAR PERSPECTIVE deals with the appearance of objects as expressed by outline.

In order to judge of the relative size of objects at a distance, and to be able to get the proportion of the different dimensions of an object, pupils must be taught to measure by proportion. Take one side of a book cover for example. Stand the book on the desk. Draw line of any convenient length to represent one of the long edges, then two shorter lines at right angles to it. Try to make these lines the same proportion to the long one that the short edges of the book are to the long one, judging by the eye at first. Then lay the pencil, first on the short, then on the long edge of the book to see how they compare. The longer edge may be twice the shorter, or perhaps there is not so great a difference between them, however it may prove the drawing must be made to represent the same proportion.

Make frequent trial of getting the proportion of length and width of familiar objects. When the object is at a distance it cannot, of course, be tested and measured to prove the accuracy of the first estimate, but after a little practice the proportion can be obtained by the use of the pencil very satisfactorily.

Method of Measuring the Proportion of Distant Objects.

Look at the object steadily, closing one eye. Hold the pencil at right angles to the arm and at full arm's length. The pencil is held by the fingers so that the thumb is free to move along the pencil as occasion demands. To take the vertical measurement hold the pencil with the point downward, and at such a height that the upper end of the pencil appears to coincide with the upper edge of the object to be measured; then move the thumb up or down the pencil until it indicates the exact position of the lower edge of the object. Note this measurement.

In taking the horizontal measure hold the pencil point toward the right, and so that the left end of the pencil appears to cover exactly the left edge of the object to be measured; move the thumb until it indicates the position of the right edge of the object. Note this measurement and compare with the vertical measure to obtain the proportion. Make the drawing whatever size best suits the space to be used, keeping the proportions carefully.

When pupils understand drawing by proportion, they may begin to represent foreshortened surfaces.

Let each observe, carefully, some rectilinear object placed directly in front of him, or "in the line of direction" and below the level of the eye.

The vertical face appears its true shape. Let it be so represented; the proportion of length and width to be obtained as before stated.

The top face of the object is in a horizontal position, below the eye, therefore it will be seen obliquely, and appear foreshortened.

First, we must get the width of the top face from front to back. Hold the pencil as for taking a vertical measurement, the top of the

pencil just covering the farther horizontal edge; with the thumb indicate the position of the nearer horizontal edge. Find the proportion of this measure to either dimension of the vertical face of the object, and place a horizontal line at a distance above the nearer horizontal edge, corresponding to the proportion indicated. The top face of the object may be several times as wide as the vertical face and yet not appear as wide.

NEXT, hold the pencil as for horizontal measure and take the width of the nearer horizontal edge, then of the farther one to see if they are the same length. We find that the farther one appears shorter. This tells us that the parallel-horizontal edges which are at right angles to the vertical face, do not appear as parallel edges, but appear to approach each other or converge, as they recede from the eye.

This important principle — *that parallel lines retreating from the eye appear to converge* — is sometimes difficult to explain clearly.

Pupils are sometimes unable to understand when small objects are used as illustration, in that case, have pupil take position in the front part of the room opposite the space between two rows of desks.

Let him measure the width between the front desks, then between the last two in the lines, and he can hardly fail to see the truth of the principle.

A street with high buildings on either side is a good place to study the convergence of parallel lines, and if the street is long and the view uninterrupted it will be seen that all these lines converge at a single point on the horizon — called a *vanishing point*. In parallel perspective there is but one vanishing point for the retreating horizontal lines and it is found at a point directly opposite the observer in the horizontal line, which is always on a level with the eye.

Figure 4 illustrates the convergence of parallel lines retreating from the eye. The observer in this case is at quite a distance above the level of the floor and midway between the sides of the room. The dotted line, H L, represents the horizontal line. The point directly opposite the observer on that line is called the *centre of vision*, and is the vanishing point for horizontal lines retreating from

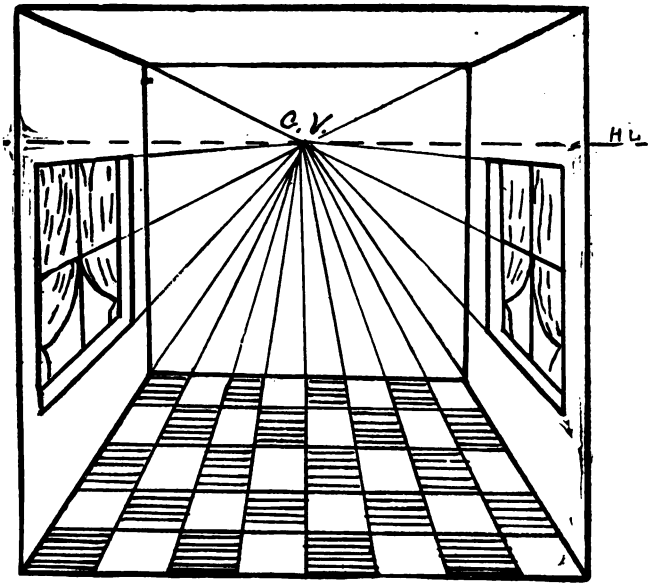


FIG. 4.

the eye. Light lines show the horizontals extended to the vanishing point. It will be seen that the horizontal lines above the level of the eye tend downward toward the *horizontal line* (lines showing

the contact of ceiling and side wall,) while those below tend upward to the same line.

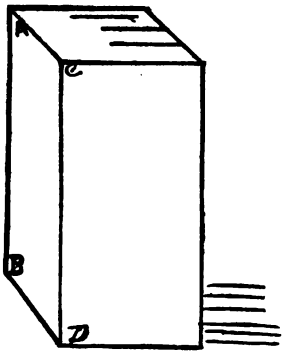


FIG. 5.

When the object is placed so that we see three faces, the front vertical face still appearing its true shape, and having learned how to represent the top face foreshortened, only the third face remains for us to study. Take the width of the second vertical face, from right to left, with pencil held as for horizontal measurement. Draw a vertical at the distance determined from the front edge. We will probably *see* this face much narrower than its true width. Then take the length of the farther vertical, (*a b*, Fig. 5,) and compare it with the nearer vertical (*c d*). It will appear shorter, again showing the converging lines in place of the parallel ones of the object. Notice how high the lower corner at the back comes up on the vertical at the front, place a point on the vertical already drawn to represent the farther edge, at the height indicated. Note, next, how much higher the corner at the back is than at the front, and place a

point on the vertical representing the farther edge. Having these guide points it is very easy to complete the drawing.

Again objects may be so placed that none of the faces are parallel to the observer, and so none appear their true shape.

The object should be placed so that the horizontal edges will make angles of forty-five degrees with the long edge of the desk.

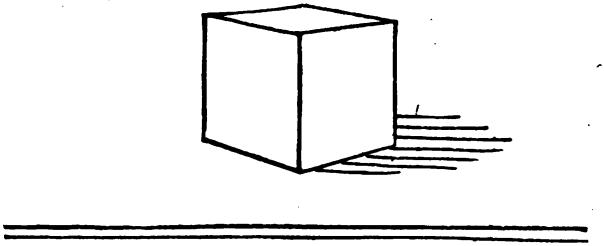


FIG. 6.

The vertical edges appear vertical, but all the horizontal edges incline upward to the left and right. Note the height of the vertical edges to the left and right, then draw the vertical faces. Notice how high the lower corners come on the nearest vertical, also how much higher the upper corners to right and left are than the one nearest. Draw the object by proportion, the top face last. Extend the horizontals to see that they converge; it is not necessary to produce them to the vanishing points. It will be seen that objects placed in this and similar positions have two vanishing points, one for lines on the right, the other for lines on the left; both are in *the horizontal line*. An object placed as Fig. 6 is in *angular perspective*.

Endeavor to make these points clear and give frequent exercises in taking measurements from objects before giving rules or terms in perspective; rules are much more easily learned when they seem to be simply the result of experience.

A Few Terms and Some Simple Rules Used in Linear Perspective.

PICTURE PLANE.— A vertical transparent plane between the objects and the observer on which the drawing is supposed to be made. The flat surface on which the drawing is actually made takes the place of this imaginary plane.

GROUND PLANE.— The surface upon which the objects are supposed to rest.

HORIZONTAL LINE.— An imaginary line on the picture plane on a level with the eye of the observer.

CENTRE OF VISION.— A point on the horizontal line directly opposite the observer.

VANISHING POINTS.— Points in the picture plane at which retreating lines appear to vanish.

PARALLEL PERSPECTIVE deals with objects whose lines are either parallel with or perpendicular to the picture plane.

ANGULAR PERSPECTIVE deals with objects whose lines are either vertical or horizontal, the latter making angles with the picture plane other than right angles.

OBLIQUE PERSPECTIVE deals with lines which are oblique to both the ground plane and the picture plane.

LINEAR PERSPECTIVE treats of the appearance of objects expressed by outline; it includes parallel, angular and oblique perspective.

RULES.

1. Lines which are parallel with the picture plane have no vanishing point.
2. Parallel lines retreating from the eye appear to converge, and if extended will meet at points called *vanishing points*.
3. All lines which are parallel to each other have the same vanishing point.
4. Lines which are perpendicular to the picture plane vanish in the *centre of vision*.
5. All horizontal lines making angles with the picture plane vanish in the *horizontal line*.
6. A circle viewed obliquely appears an ellipse.

DECORATION.

"*Decoration is the art of adorning, or embellishing.*"
— WEBSTER.

Decoration as applied to the third department of industrial drawing, relates to the production of beauty in ornament.

Only the elementary principles of design can be taught in the limited time allotted to the study in connection with other school work.

Elementary Design is an exercise in arranging given forms in new and original combinations. Any form that is repeated to make a design is called *a unit of design.*

The first principle to be considered is *symmetry* — the equal balance of two halves — either of the unit on its axis, or of the unit or combination of units on either side of the axis of symmetry. Equal balance is pleasing to the eye; even forms and lines not beautiful in themselves become interesting when perfectly balanced on opposite sides of a straight line or axis.

The second principle is *repetition.*

A unit however simple, provided it be distinct, repeated at regular intervals must result in some gracefulness of effect.

It will of course be true that the more beautiful the unit of repetition, the better the effect of the whole.

Repetition may be
- *Simple.*—When same unit is used again and again.
- *Alternate.*—When two units are used alternately.
- *Combined.*—When several units are employed.

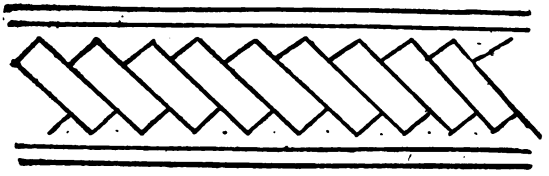


FIG. 1.

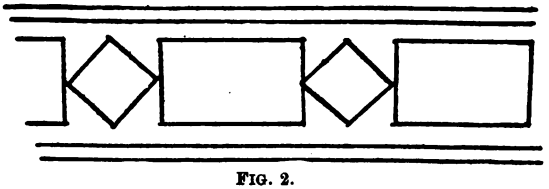


FIG. 2.

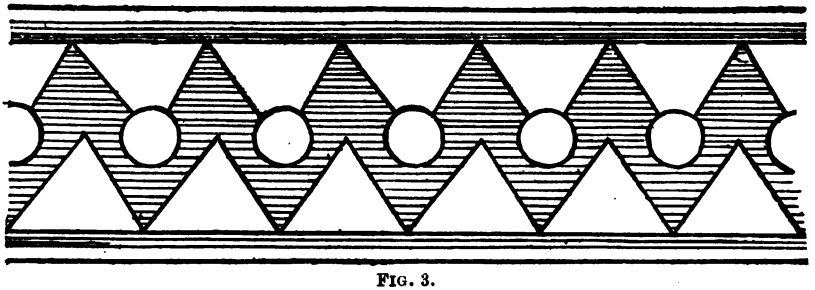


FIG. 3.

These terms may be illustrated by the use of tablets in the form of the plane geometric figures, made either of board or paper. Pupils should each be supplied with a number of these tablets with which to make original combinations, as a test of their comprehension of the subject. Or the teacher may draw a number of forms on the black-board to be used, in the different ways mentioned as a drawing exercise.

Simple repetition shown in Fig. 1.

Alternate repetition shown in Fig. 2.

Combined repetition shown in Fig. 3.

In commencing instruction in design the size and form of the space to be filled by the design, should be given to the pupil as well as the units to be repeated.

Next the modes of arranging the units should be explained — and then the way to divide the surface for repetition of the design.

Modes of arrangement.

1. In a straight line (Fig. 11) a border.
2. About a centre (Fig. 10) a rosette.
3. To cover a surface (Fig. 12) all over design.
4. On an axis (Fig. 13) bi-lateral symmetry.

Whatever mode is selected, the surface should be first divided into equal parts, the shape to be determined by the outline of the surface to be decorated, and the manner of arranging the design. A border may be divided into equal squares, oblongs, triangles, or any plane geometric figure that best suits the form we have in mind; in each one repeat the design.

If a surface is to be covered with an "all-over" design, it must repeat at regular intervals, so the simplest method is to divide the space either into figures that repeat, leaving no spaces between (Fig. 4), or into figures that repeat regularly leaving spaces of pleasing

shape between (Fig. 5), then placing the design in each of these divisions or in alternate ones.

If we wish to place a design in rosette form within these spaces, we draw either the diagonals or diameters of the figure, or as many axes of symmetry as it has sides, and in the spaces or "fields" thus formed, repeat the unit. If the design is to be made within a circle

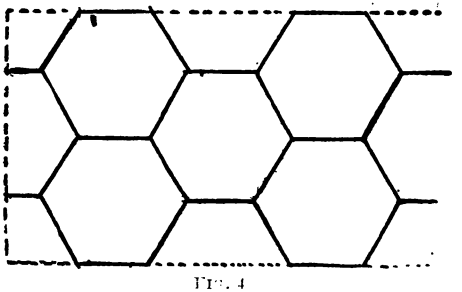


FIG. 4

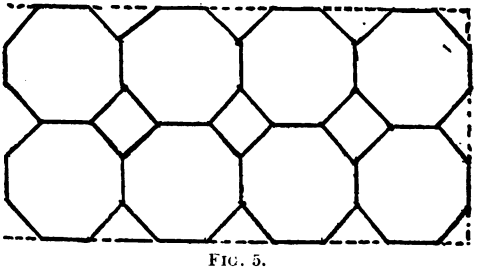


FIG. 5.

draw radii using each as the axis of a unit of the design. Study carefully the proportion of the ornament to the space to be occupied by it. Two-thirds of the space filled by the ornament, one-third for the background, is a good rule.

When units are repeated "about a centre" the central form should be strong, and the main lines of the repeated form should tend toward the centre, but never join it by a single line, for that weakens the

effect of the design. Avoid all meaningless lines which enclose no form, also all effort toward complicated arrangements.

The first requisite in elementary design is *simplicity*. Aim to have a few pleasing forms well drawn. "With young pupils when the exercise is mainly for the purpose of teaching drawing and arrangement, the work should be done free-hand; older pupils should be taught that design to be of practical value must be accurate."

Decorative design should always express strength and repose; so all combinations that produce a whirling effect should be avoided, also all containing many lines and small disconnected figures.

When color is not used in the ornament, half-tint lines may mark more clearly the distinction between background and ornament. These lines must be in the same direction throughout the figure; they may be either vertical or horizontal. The design should not touch the outline of the space at any point, and the margin should be of nearly uniform width.

Sources of Ornament. { Geometry, / Nature, } Historic Ornament.

Historic ornament is the chief study of the modern designer; but its origin was in the two sources Nature and Geometry, which still possess untold combinations of beautiful forms for him who has been trained to see them. The ancients seldom used natural forms for ornament unless highly conventionalized.

Conventionalization consists in making an ornamental form from the natural one without destroying its characteristics.

How to Study a Plant.

- *Observe.*
  - Leaf,
    - Edge,
      - Dentate,
      - Lobed,
      - Smooth, etc.
    - Veining,
      - Midrib,
      - Ribs,
      - Veins, Veinlets.
    - Stem,
  - Flower,
    - Corolla,
      - Petals,
      - Stamens,
      - Pistils.
    - Calyx,
      - Sepals,
      - Seed-sac, etc.

Draw front, back, and side-view of leaf.

Draw front, back, and side-view of flower.

Draw front, back, and side-view of bud.

Notice if flowers grows singly or in clusters, and whether leaves grow opposite or alternate. Note also the character of growth, whether upright or reclining, stiff or twining, for in conventionalizing the plant or flower we must violate none of its characteristics. In conventionalizing, the irregularities of growth are omitted, all that is characteristic of the type is preserved. *Example.*—If a leaf is strongly dentate make slight irregularity in the outline; if the edge of the leaf is only slightly irregular make the conventional with a smooth edge. In teaching design from natural foliage the exact principle of the growth of the leaves on the stem should be adhered to, if there is space enough, to show the stem with leaves connected. If there is not room to do so, the leaves may be used separately as any other units would be, showing stems connected with some common source — as the centre ornament, if they are repeated about a centre;

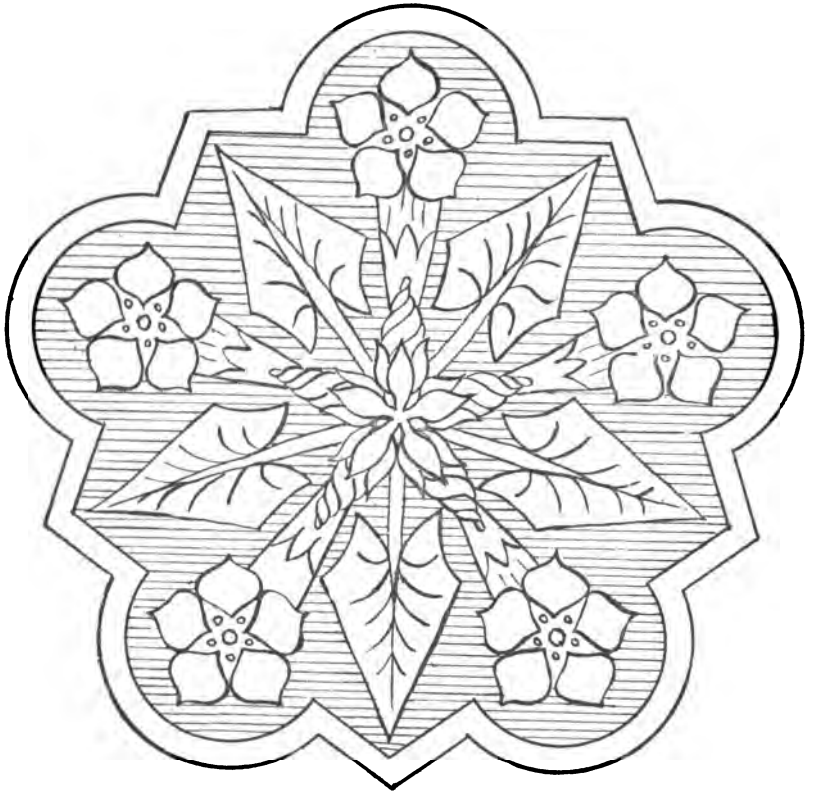


FIG. 10 *a*.

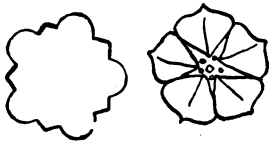


FIG. 6.

FIG. 7.

FIG. 8.

FIG. 9

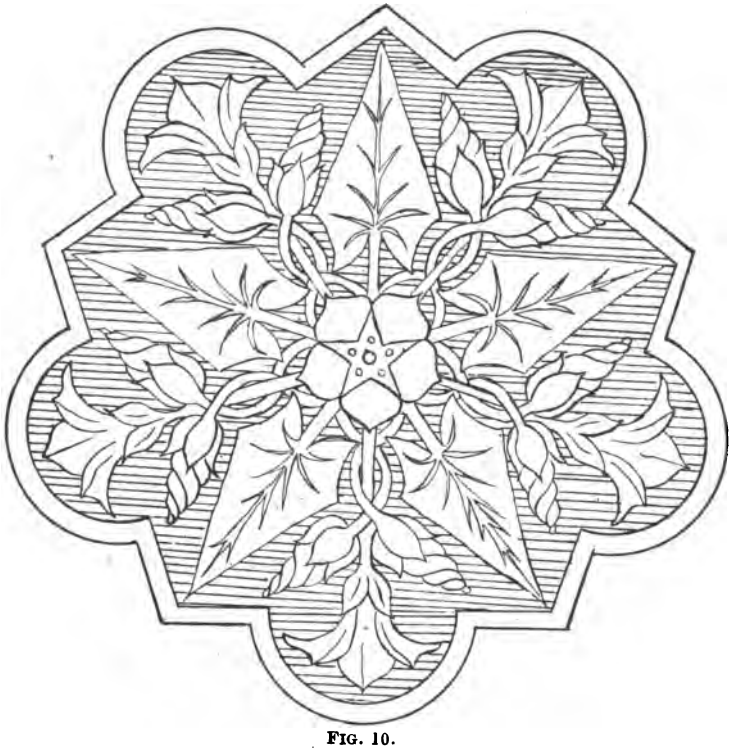


FIG. 10.

or if repeated in line, the stems must be arranged so as to suggest relation to the main stem though it may not be in sight.

These illustrations, (Figs. 6, 7, 8, 9,) taken in part from the Grammar of Ornament, show the practice of drawing parts of the plant separately, a knowledge of which should precede designing. Accompanying the natural forms is a geometric outline — a regular pentagon with semi-circles covering half of each side — in which the material might be used. One arrangement is given in Fig. 10; a simpler one in Fig. 10*a*.

Upper classes may be given these exercises in botanical drawing from the black-board, or better still from the flower itself. The size and form of the space the design is to fill should be given at the same time. Then in the leisure between the lessons pupils can make sketches of designs for the next lesson and bring to the class for criticism. Another drawing can then be made in class avoiding the faults of the first.

To fix in memory the characteristics of different leaves and plants, give the name of parts as the pupils are drawing them, calling attention to the striking peculiarities of each. Then require each pupil to gather, press, label, and bring to the class-room specimens of all used in the drawing lessons.

It is sometimes well to use the same leaf or form to fill outlines of quite different shape, and arrange the same form in different ways rather than take a new subject each time. (*Example.*— Figs. 11, 12, 13.) One advantage is that pupils learn to draw one form *well*, and another is that they learn its adaptability to several purposes.

Another source of material for design is in snow crystals. They are the most remarkable examples of repetition on the power of six. Elaborate borders may be arranged from forms suggested by snow crystals.

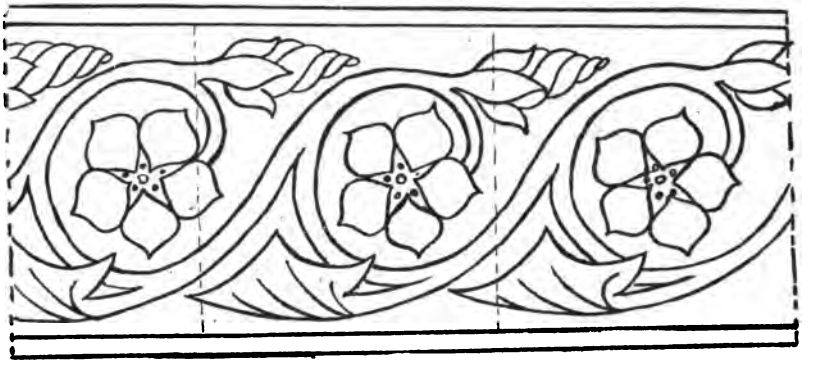


FIG. 11.

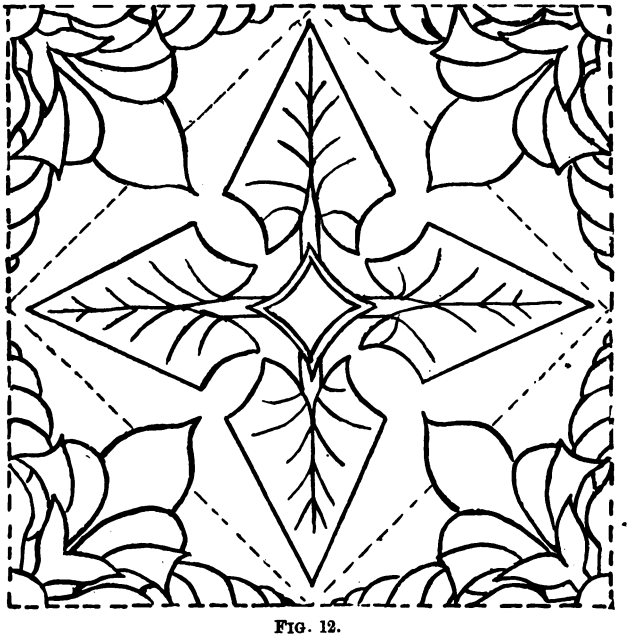


FIG. 12.

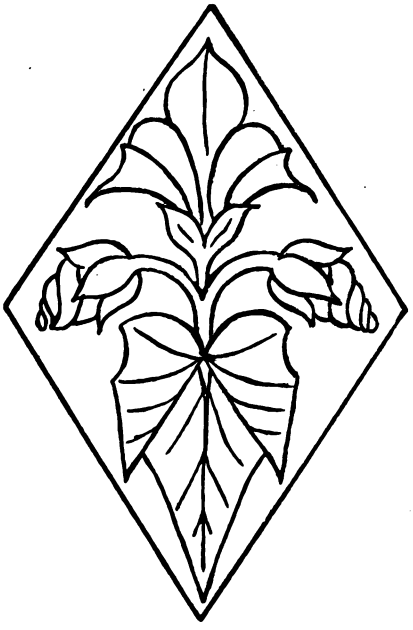


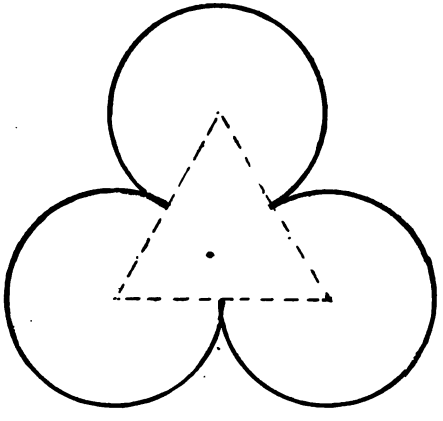
FIG. 13.

In enlarging these forms the space must be accurately divided into six parts before any details of form are attempted. This may be done by drawing the hexagon with its diagonals, or by drawing a circle and dividing its circumference into six equal parts with lines connecting these points with the centre. "Cloud Crystals," or "A Snow-flake Album," give many illustrations of snow crystals.

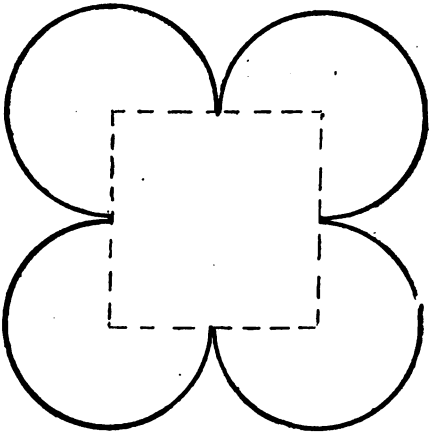
"Good drawing depends upon the development of the observing powers — unless the eye sees intelligently, the cultivated hand is of little use to its possessor."

DICTATION EXERCISES.

Dictation exercises are of great value in cultivating the memory with reference to form. The examples given are enclosed within forms capable of being exactly expressed by words; through their use pupils become familiar with the modes of arrangement, symmetry, repetition, proportion, and soon acquire the ability to draw from impressions received through the ear as readily as from those received through the eye.



TREFOIL.—Draw an equilateral triangle. Using each angle as a centre and with a radius equal to one-half the side of the triangle, draw part of a circle, beginning at the middle of one side and extending to the centre of the adjacent side. The triangle may be erased.



QUATREFOIL.—Draw a square, and bisect its sides. Using each corner as centre and with a radius equal to one-half a side, draw parts of circles, beginning at the middle of one side and extending to the middle of the adjacent side. The square may be erased.

These forms make good outlines in which to place designs.

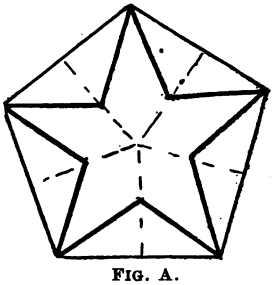


FIG. A.

FIGURE A.—Construct a regular pentagon. Draw the five axes of symmetry. Bisect the short part of each axis and connect these points with the nearest angles of the pentagon by oblique lines, to form a five-pointed star.

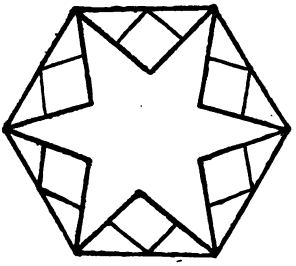


FIG. B.

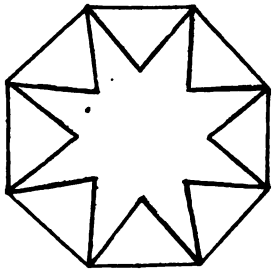


FIG. C.

FIGURE B.—Construct a regular hexagon. Draw the diameter and bisect each semi-diameter. Connect the points of bisection with the nearest angles by oblique lines. Result, a six-pointed star. This may be elaborated by bisecting each side of the points of the star, and connecting the points with the extremity of the nearest semi-diameter, as shown in the light lines.

FIGURE C.—Draw as quare and its diagonals. Mark from each corner on the adacent sides the length of a semi-diagonal. Connect the points to form an octagon. Draw the diameters of the octagon. Bisect each semi-diameter. Connect these points with the nearest angles of the octagon. Result, eight-pointed star.

DICTATION (FIG. 1).—Draw two horizontal lines six inches long and two inches apart. Trisect each of these lines and connect the points of trisection by verticals, dividing the space into three squares. Three-quarters of an inch above the lower horizontal draw another parallel to it. This line is divided into three equal parts by the vertical, — construct semi-circles curving upward on each of the three

divisions. Trisect the first or left hand division, and use the inner third as the base of an equilateral triangle. Construct the triangle, and on it form a trefoil. On the lower side of the line draw two semi-circles curving downward each having one-half the line for base or diameter. Repeat in the other two divisions.

Erase the third horizontal, the verticals and the triangles.

Half-tint the background.

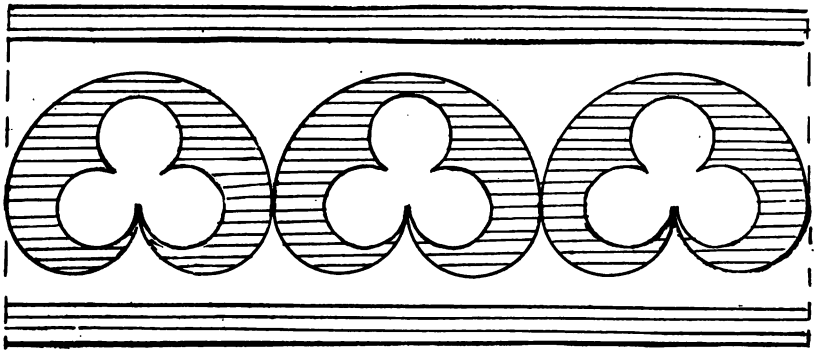


FIG. 1.

DICTATION (FIG. 2).—Draw two horizontal lines six inches long and two inches apart. Trisect each line, and connect the points of trisection by short verticals dividing the space into three squares. Draw the diameters of each square, and connect the ends of the diameters by oblique lines forming three squares on their diagonals. Bisect the diagonals and connect the points by oblique lines forming smaller squares within the larger. Draw the diagonals of the first three squares into which the space was divided. These diagonals,

connecting as they do, form other squares on their diagonals overlapping the first set. Bisect the diagonals and connect the points by oblique lines to form smaller squares within as in the first case.

Erase the small portions of the sides of the squares necessary to make them interlace regularly. An eighth of an inch outside the first horizontals draw two others, and a quarter of an inch outside, two more.

Erase the first horizontal lines and the verticals, also the diameters and diagonals of the squares.

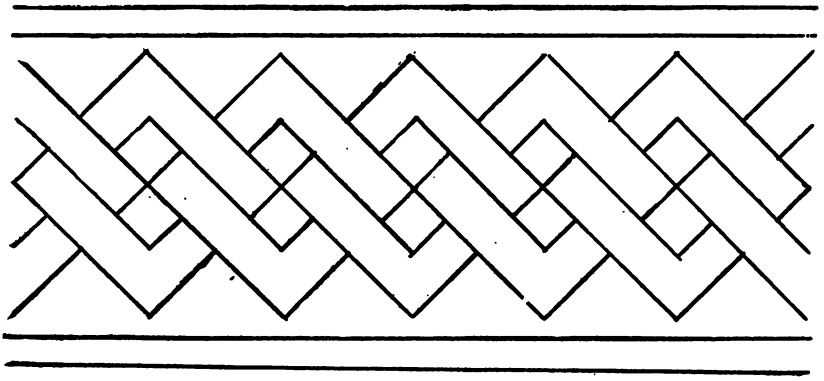


FIG. 2.

DICTATION (FIG. 3).— Construct a four-inch square.

Draw the diameters of the square, and bisect each semi-diameter.

Bisect the inner half of each semi-diameter. Connect the last points by oblique lines forming a square on its diagonals for the central figure of the design.

Quadrisect each side of the square, and connect the outer points

of quadrisection on adjacent sides by oblique lines. Quadrisect these lines and connect the upper point of quadrisection in the upper left corner with the upper point in the right corner by a horizontal line. Connect these same points with the centre by oblique lines. Repeat on the other semi-diameters.

Erase the diameters, the oblique lines across the corners, and all lines within the centre square.

Line in the units and the centre square.

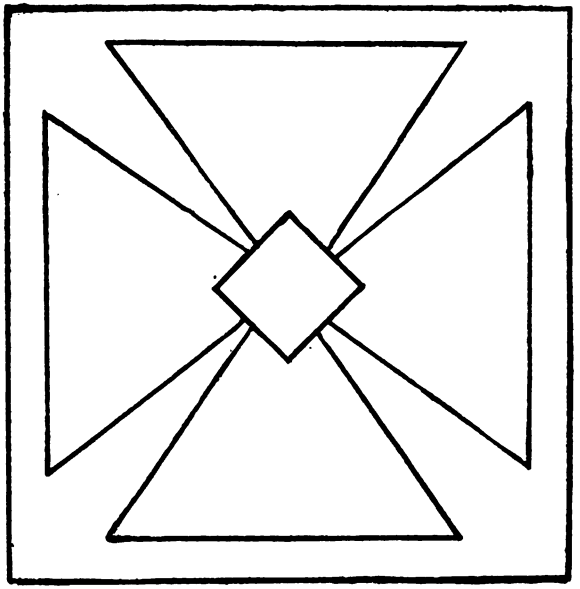


FIG. 3.

DICTATION (FIG. 4).— Draw an equilateral triangle. Draw the three axes of symmetry. Quadrisect the short part of each axis, and through the points of quadrisection nearest the centre draw a circle.

A quarter of an inch within the first triangle draw a second with sides parallel to the first. Quadrisect the upper half of the left and right sides of the inner triangle. Connect the points of quadrisection nearest the middle of each side with the centre of the triangle by oblique lines. These lines with the part of the triangle included, form the unit to be repeated on the other two axes.

Erase the axes of symmetry, the parts of the second triangle not included in the units, and the lines within the circle.

Line in the outer triangle, the units of design and the circle.

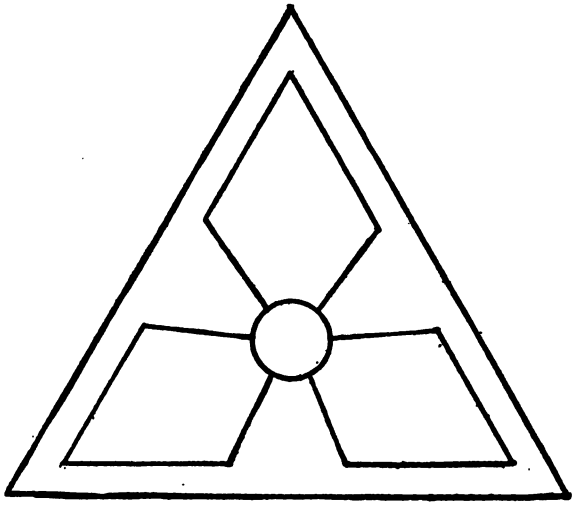


FIG. 4.

DICTATION (FIG. 5).—Draw a four-inch square. Draw the diameters and diagonals. Place a point on each diagonal one-quarter inch from the end. Connect these points to form a second square with

sides parallel to the first. Connect the ends of the diameters by oblique lines to form a third square. Quadrisect each side of the third square. Bisect the outer half of each semi-diagonal, and connect these points by horizontal and vertical lines with the outer points of quadrisection on the sides of the third square. Connect the outer points of quadrisection on each side of the square with the

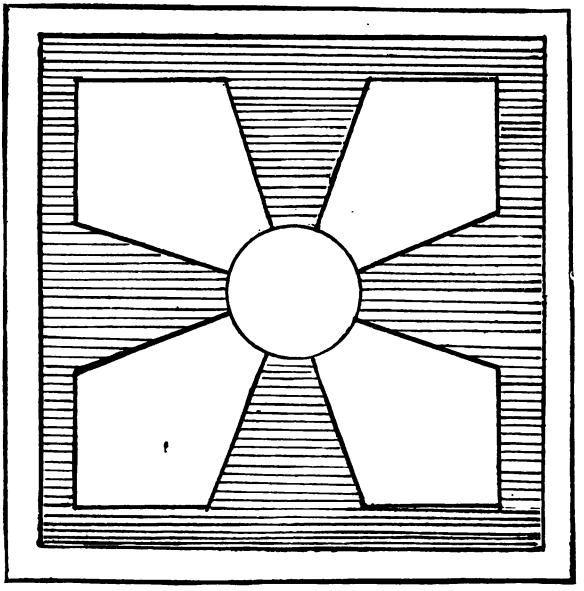


FIG. 5.

centre by oblique lines. Bisect each semi-diameter of the first square. Bisect the inner half of each semi-diameter and through these points sketch a circle.

Erase the diameters, diagonals, the third square and all lines within the circle.

Line in first and second squares, the units of the design and the central circle.

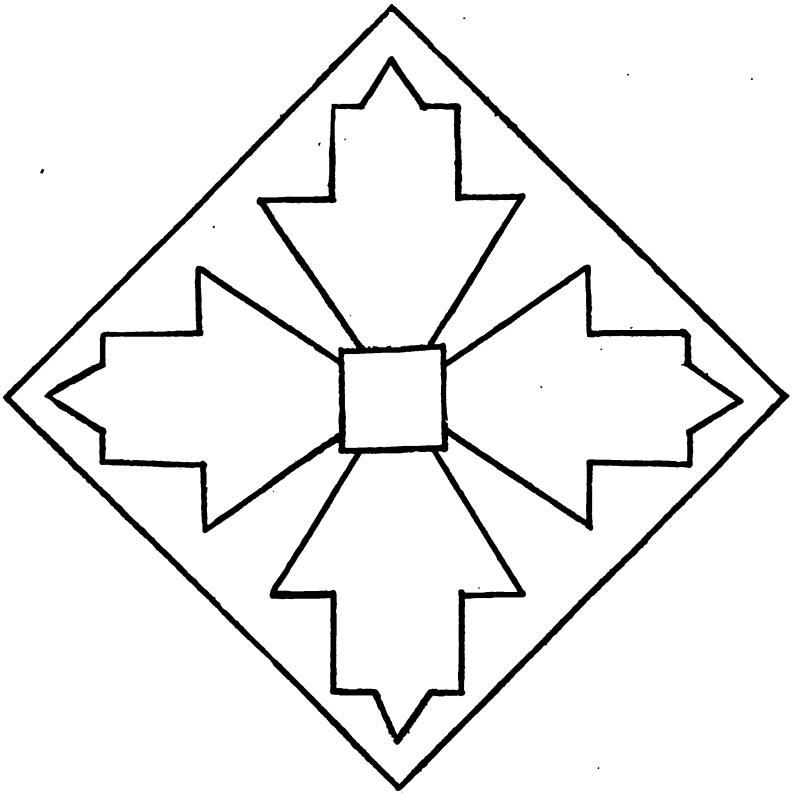


FIG. 6.

DICTATION (FIG. 6).— Draw a four-inch square, on its diagonal. (Simplest way is to draw two five-and-one-half-inch lines crossing at their centres at right angles, and connecting the ends of these lines by

oblique lines). Draw the diameters and connect the ends by vertical and horizontal lines to form a second square. Divide each side of the second square into six equal parts. Quadrisect the sides of the first square, and connect the outer points of quadrisection on adjacent sides by vertical and horizontal lines. Divide each of these lines into six equal parts. The semi-diagonals are to be the axes of symmetry on which the units are to be balanced. Place a point on the left semi-diagonal half-way between the left angle and the vertical that crosses the semi-diagonal. Connect this point with the two points nearest the centre of the vertical by short oblique lines. Connect the two outer points on this line with the two points nearest the centre of the left side of the second square by horizontal lines. The two outer points on the left side of the square are to be connected with the centre by oblique lines. Repeat on other semi-diagonals. Quadrisect each semi-diameter of the first square, and connect the inner points by vertical and horizontal lines to form a third square.

Erase all lines within the centre square, the diameters and diagonals, all of the second square, except the parts included between the first and second, and the fourth and fifth points of division, the parts of the short vertical and horizontal lines crossing the corners, not included between the first and second, and the fourth and fifth points of division.

DICTATION (FIG. 7). — Draw two verticals two inches apart. Connect the upper ends by a horizontal line. Place a point on each line two inches from the top, connect the points by a horizontal. Two inches below draw another horizontal, and so on until the space between the lines is divided into two-inch squares. Draw the diameters of the upper square. Connect the upper end of the vertical diameter with

the ends of the horizontal diameter by oblique lines. Connect the centre of the square with the two lower corners by lines parallel with those last drawn. Bisect each of these oblique lines. Construct a

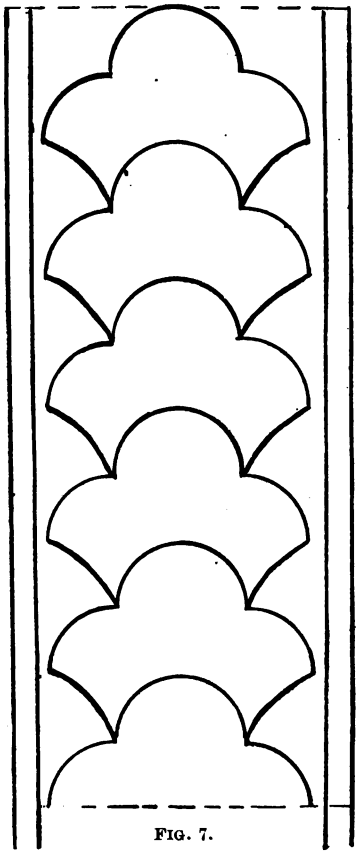


FIG. 7.

semi-circle passing through the upper extremity of the vertical diameter and ending in the points of bisection of the two upper

oblique lines. Draw quadrants connecting the points of bisection on the two upper oblique lines with the ends of the horizontal diameter. Connect the ends of the horizontal diameter with the points of bisection on the two lower oblique lines by lines curving inward. Repeat in each half square. In the lower half of the square the semi-circle passes through the centre of the square. Draw two verticals an eighth of an inch outside the first two, and a quarter of an inch outside two more.

Erase first verticals, horizontal lines, and diameters of the squares.

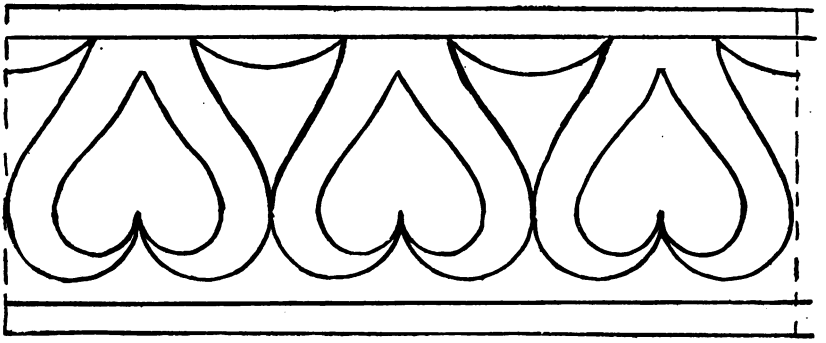


FIG. 8.

DICTATION (FIG. 8).— Draw two horizontal lines six inches long, two inches apart. Trisect each line and connect the points by verticals thus dividing the space into three two-inch squares. Trisect the vertical sides of the left-hand square, and connect the lower points by a horizontal line. Bisect this line, and on each half construct a semi-circle curving downward. Trisect each half of the same line, and draw semi-circles curving downward covering the two divisions nearest the centre on each side. Draw the vertical diameter of the

square. Place a point a quarter of an inch from the upper end of the diameter. Connect the point with the outer ends of the smaller semi-circles by curved lines. Trisect the upper side of the square. Connect the points of trisection with the outer ends of the larger semi-circles by curved lines. Connect the nearest points of trisection in adjacent squares by lines curving downward.

Erase all straight lines except the first two horizontals.

Line in all the curved lines. A quarter of an inch outside the first horizontals draw parallels.

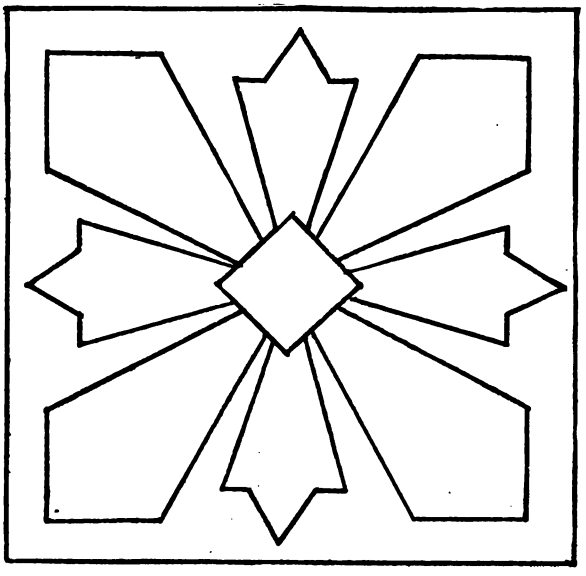


FIG. 9.

DICTATION (FIG. 9).— Construct a four-inch square. Draw the diameters, and diagonals. One-quarter of an inch within the first

square draw a second with sides parallel to the first. Quadrisect each side of the second square, and connect the points of quadrisection nearest the upper left hand corner with the centre of the square by oblique lines. These lines with the part of the second square included form the unit to be repeated on the other diagonals. Quadrisect each semi-diameter of the outer square, and connect the inner points of quadrisection by oblique lines forming a square on its diagonals, this is the central ornament. Through the outer point of quadrisection on the upper semi-diameter draw a horizontal line equal in length to one-fourth of a semi-diagonal. Connect the ends of this line with the centre of the square by oblique lines. Bisect each half of the horizontal line, and connect these points with point on the diameter half-way between the first and second squares by short oblique lines. Repeat on the other semi-diameters.

Erase diameters, diagonals, all lines within the centre square, all of the second square not included in the units repeated on the diagonals, and the inner half of the horizontal line in the units repeated on the diameters.

Line in the centre square and the units of design.

DICTATION (FIG. 10).—Draw an equilateral triangle, four-inch sides. Quadrisect the sides and construct a semi-circle curving outward on each side, having the two-fourths nearest the middle of the side, for base or diameter. Draw a circle one-half inch in diameter in the centre of the triangle. Divide the diameters of the semi-circles into six equal parts, and draw semi-circles curving outward covering four of these divisions. Connect the ends of the smaller semi-circles with the centre by lines curving slightly outward. Draw the three axes of symmetry, and quadrisect the longer part of each, that is, the

part extending from the centre to the angle of the triangle. Connect the outer points of quadrisection, also the middle points by lines parallel to the sides of the first triangle.

Erase the axes of symmetry, the parts of the first triangle within the semi-circles, parts of the two inner triangles extending over half the unit, and all lines within the circle.

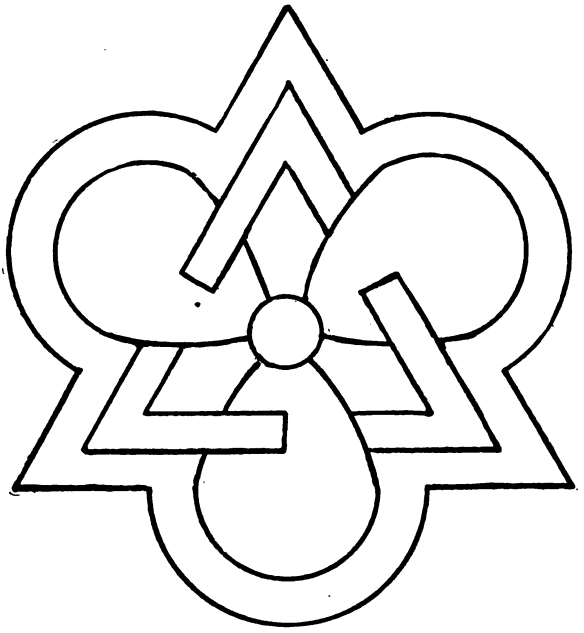


FIG. 10.

Line in the outline, the units, circle, and the two triangles that form the band interwoven with the units, and the short line connecting the ends of the triangles at the centre of the units.

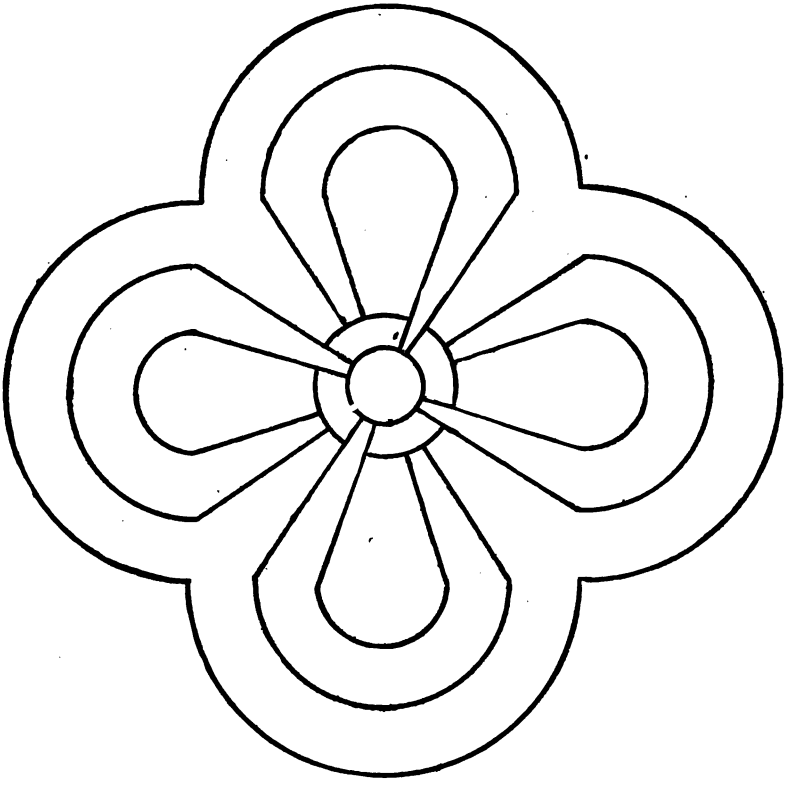


FIG. 11.

DICTATION (FIG. 11).—Draw a square on its diagonals. Draw the diameters. Connect the ends of the diameters to form a second square. Construct semi-circles curving outward on each side of the second square; they will pass through the corners of the first square. These semi-circles form the outline in which the design is to be placed. Quadrisect the semi-diagonals of the second square, and

through the inner points draw a circle. Within draw another circle having a diameter equal to one-half the diameter of the outer circle. Divide each side of the second square into six equal parts. On the upper side of the second square construct a semi-circle having the four inner divisions as base, or diameter, and within it another semi-circle having the two inner divisions for base. Connect the left ends of the two semi-circles by oblique lines with the outer circle in the centre of the figure. Connect the right ends with the inner circle by oblique lines, and the small part of the outer circle included between them is to be erased. Repeat on the other three sides.

Erase the two squares, the diameters, and diagonals.

Line in the semi-circles, oblique lines, and central circles.

DICTATION (FIG. 12).—Construct a square on its diagonals. Size, four inches. Draw the diameters, and extend beyond the square until they equal the diagonals in length. Connect the ends of the extended diameters by vertical and horizontal lines. Erase parts of lines falling within the first square. This forms the outline of the space to be filled by the design. Quadrisect the semi-diameters of the square, and connect the inner points of quadrisection by vertical and horizontal lines to form a small square. Extend the diameters of the small square until they equal the diagonals, and connect as in the large square; this gives the centre of the design. Place points on the upper left-hand side of the square, one-half inch each side of the diameter. On the part of the side included between these points construct a semi-circle curving outward. Connect the ends of the semi-circle with the centre by oblique lines. Repeat on the other three sides. Bisect each semi-diagonal, and trisect the

outer half. Draw two one-inch lines at right angles to each other and intersecting at the outer point of trisection on the upper semi-diagonal. Connect the ends of these lines with the centre by oblique lines.

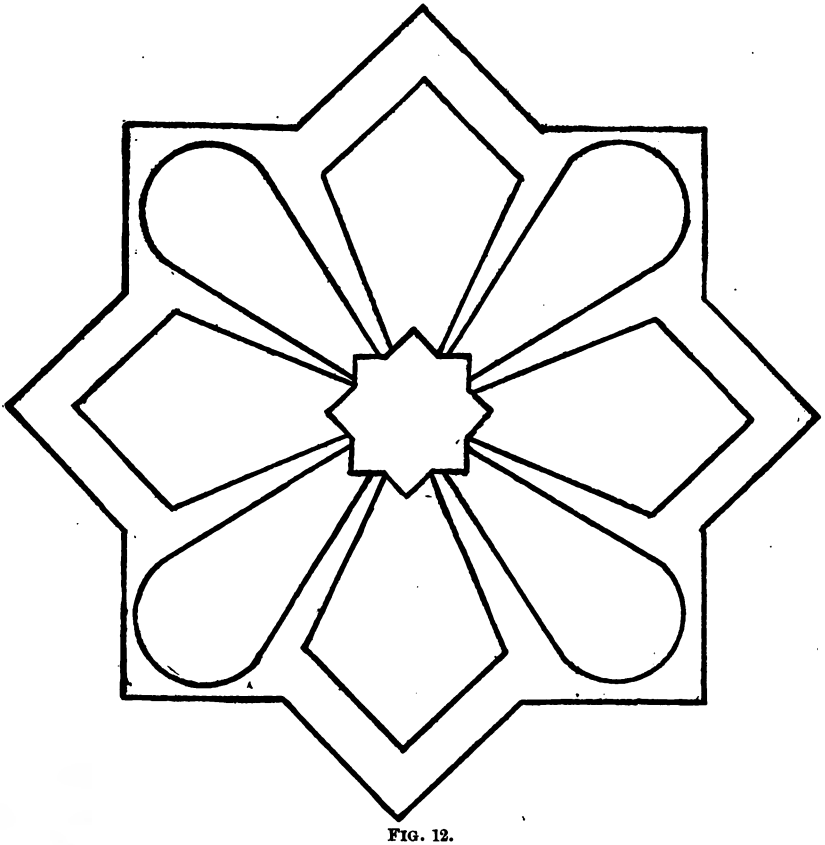


FIG. 12.

Erase the diameters, diagonals, and all lines within the central ornament.

Line in the enclosing outline, the units of design and the central figure.

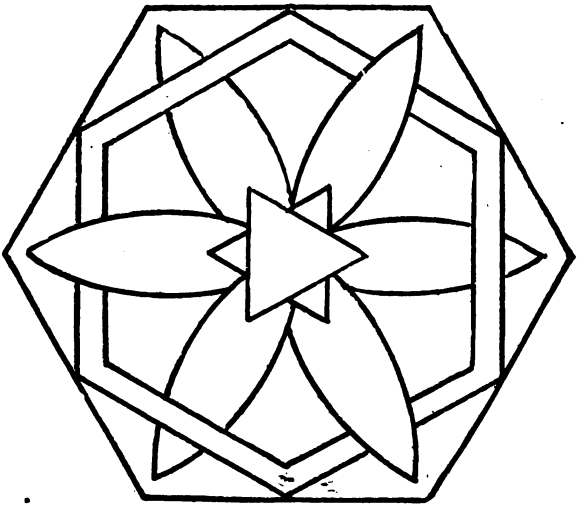


FIG. 13.

DICTATION (FIG. 13).— To construct a regular hexagon.

First Method. — Draw a circle and mark the length of the radius six times on the circumference; connecting these points by straight lines, gives a regular hexagon.

Second Method. — Draw a line either vertical or horizontal twice the length of one side of the required hexagon. Bisect the line. Upon each half construct an equilateral triangle. Connect the vertices of these triangles by a straight line and so form one-half the hexagon. Proceed in the same manner on the opposite side of the line. If the second method is used the diagonals are already drawn; quadrisect each semi-diagonal, and connect the inner points so as to

form two equilateral triangles one placed over the other. This forms the central figure. One-eighth of an inch from the end of each semi-diagonal place a point and connect it with the central figure by lines curving outward from the diagonal. Bisect each side of the hexagon and connect the points to form a second hexagon. A quarter of an inch within the second, draw a third hexagon with sides parallel to the second. These lines representing the outline of the two hexagons are to pass over and under the alternate units.

Erase the diagonals.

DICTATION (FIG. 14).—Construct a regular hexagon having two-inch sides. Draw the diameters of the hexagon and extend the lines an inch outside. Quadrisect each side of the hexagon and connect the outer points of quadrisection on each side with the end of the extended diameter, Erase the two middle divisions on each side of the hexagon. Place points a quarter of an inch from the outer end of each semi-diagonal. Connect these points forming a second hexagon. Draw the diagonals of the hexagon. Trisect each semi-diagonal and connect the inner points to form a third hexagon, within which draw a six-pointed star for the central figure. Divide each side of the second hexagon into six equal parts and connect the outer points with the central figure by oblique lines. Place points a half inch from the ends of the extended diameters. Connect these points by oblique lines with the inner points of division on the nearest side. These lines with the parts of the sides of the hexagon included, form the units of the design.

Erase the diameters, diagonals, the third hexagon, and the parts of the second not included in the units.

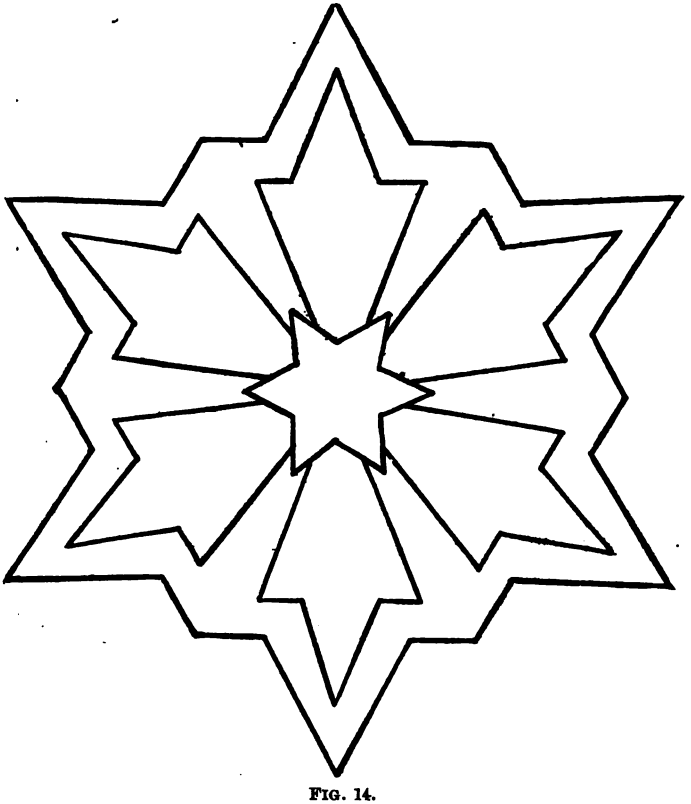


FIG. 14.

Line in the star, the units, and the outline surrounding the design.

DICTATION (FIG. 15).—Draw a vertical five inches long, and bisect it. Through the point of bisection draw a horizontal four inches long, one-half on either side the vertical. Connect the ends of these

lines by oblique lines to form a rhombus. Place points one-half inch from each end of the diagonals of the rhombus. Connect these points

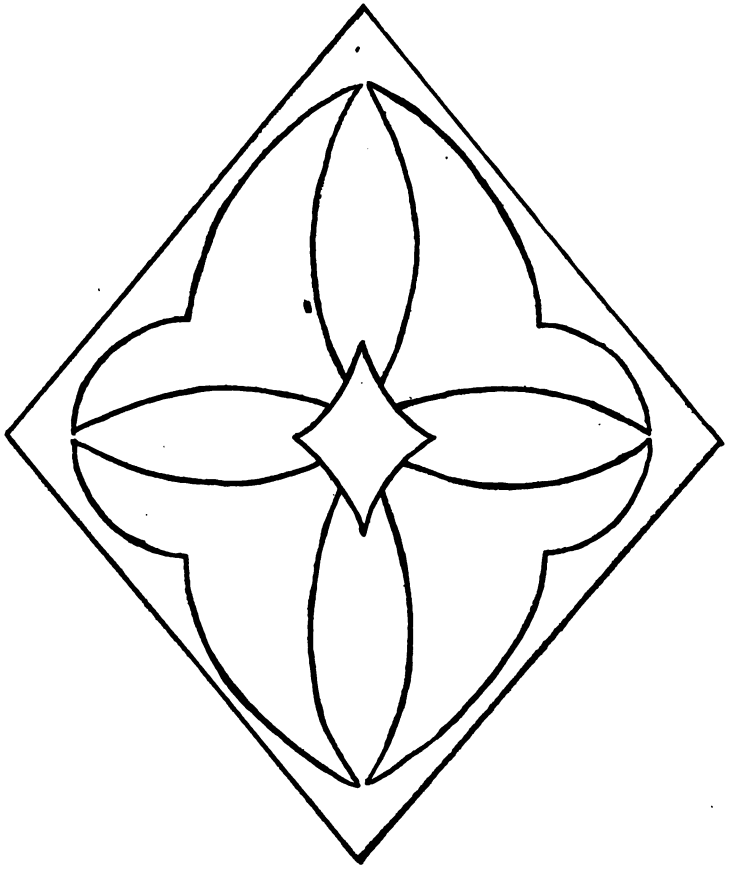


FIG. 15.

to form a second rhombus. Trisect the sides of the second rhombus. Connect the end of the upper semi-diagonal with the lower point of

trisection on the left side by a line curving slightly outward. Connect the lower point of trisection with the left end of the horizontal diagonal by a line curving outward. Connect this point with the centre by a line curving upward. Connect the end of the upper semi-diagonal with the centre by a line curving to the left. Repeat this unit on the other three sides. Quadrisect each semi-diagonal and connect the inner points by lines curving inward, to form the central figure.

Erase second rhombus, diagonals and all lines within the central figure.

Line in the units and the central figure.

DICTATION (FIG. 16).—Draw a square. Draw the diameters and diagonals. Quadrisect the sides of the square. Construct semi-circles on each side having the two inner divisions as base. Trisect the part of the upper side of the square included within the semi-circle, the middle division, or third, is to be the base of an equilateral triangle. Draw the triangle and on it construct a trefoil. With each corner of the square as centre draw a quadrant curving inward, connecting the ends of the diameters. Draw parallel curves a quarter of an inch nearer the corners of the square. Quadrisect the semi-diagonals and connect the inner points by lines curving toward the centre of the square. Place points on the diagonals a quarter of an inch from the corners. Connect the point in the upper left-hand corner with the middle of the upper and left sides of the central figure by lines curving outward from the diagonal.

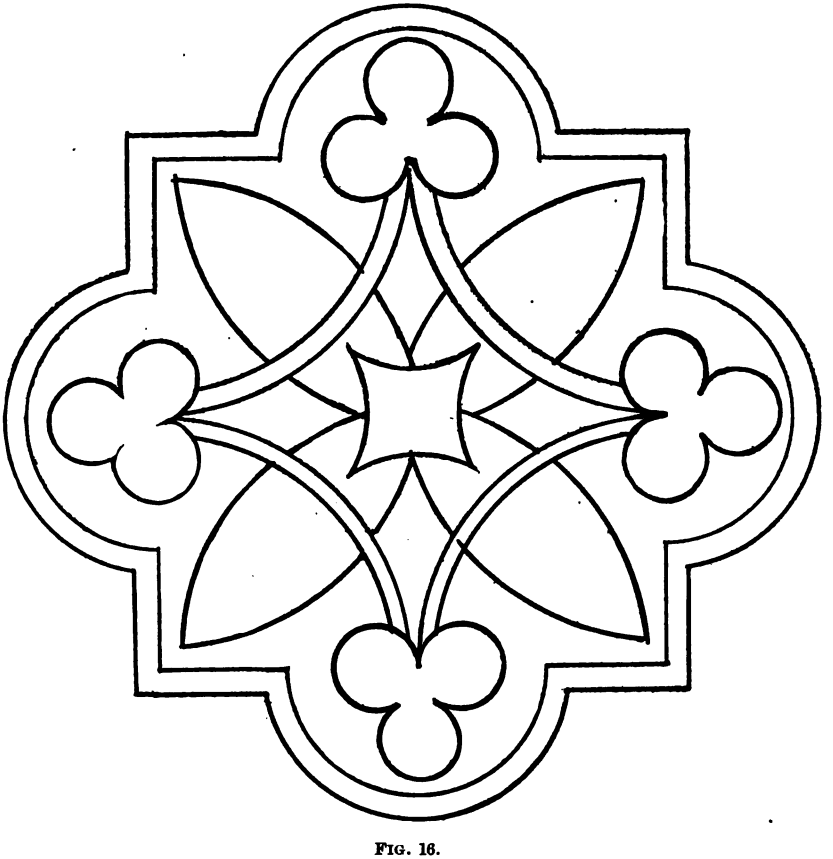


FIG. 16.

Erase diameters, diagonals, and small triangles on each side and parts of square included within the semi-circles.

DICTATION (FIG. 17).— Draw a five-inch square. Bisect the vertical sides, trisect the horizontal sides. Number these points beginning at the upper left-hand corner. Connect by oblique lines

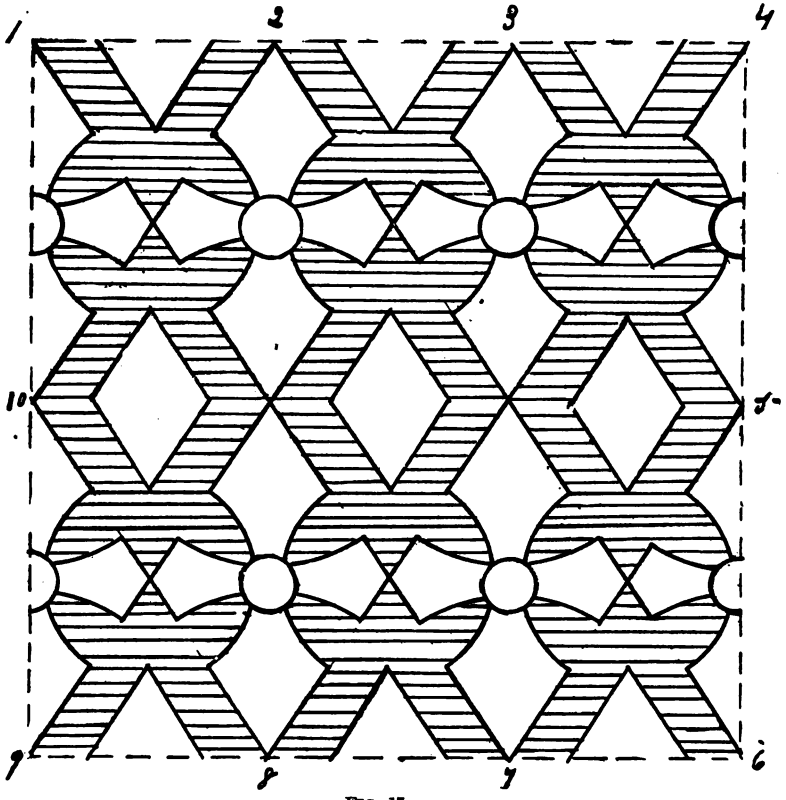
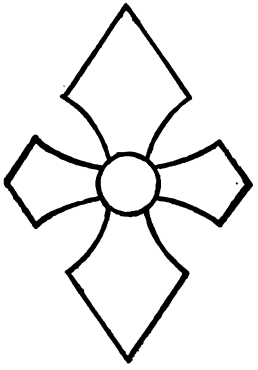


FIG. 17.

points 10 and 8; 1 and 7; 2 and 6; 3 and 5; 2 and 10; 3 and 9; 4 and 8; 5 and 7. This divides the space into figures of equal size and shape. Draw a rhombus equal to one of those formed by the oblique

lines in the square, and in this draw the unit, that is, to be repeated in alternate spaces to cover the surface given.

To form the unit of repetition. — Bisect the sides of the rhombus and connect the points with the centre by lines curving inward toward the diagonals of the rhombus. These lines with the parts of the sides of the rhombus, included, form the vertical units. Bisect the remaining half of each side and connect these points with the centre by lines curving inward toward the horizontal diagonal.



Quadrisect one-half of the short diagonal of the rhombus. The distance from the centre to the nearest point of quadrisection is the radius of the circle that forms the central ornament. Repeat this figure in the alternate divisions of the square. Draw the diagonals in the vacant spaces. Bisect each semi-diagonal and connect the points by oblique lines forming a small rhombus in each space.

Erase diagonals, and all of the oblique lines not covered by the units.

DICTATION (FIG. 18).— Construct a regular octagon with sides one and one-half inches long. Bisect each side. Take each angle of the octagon as a centre and with a radius equal to half of one side,

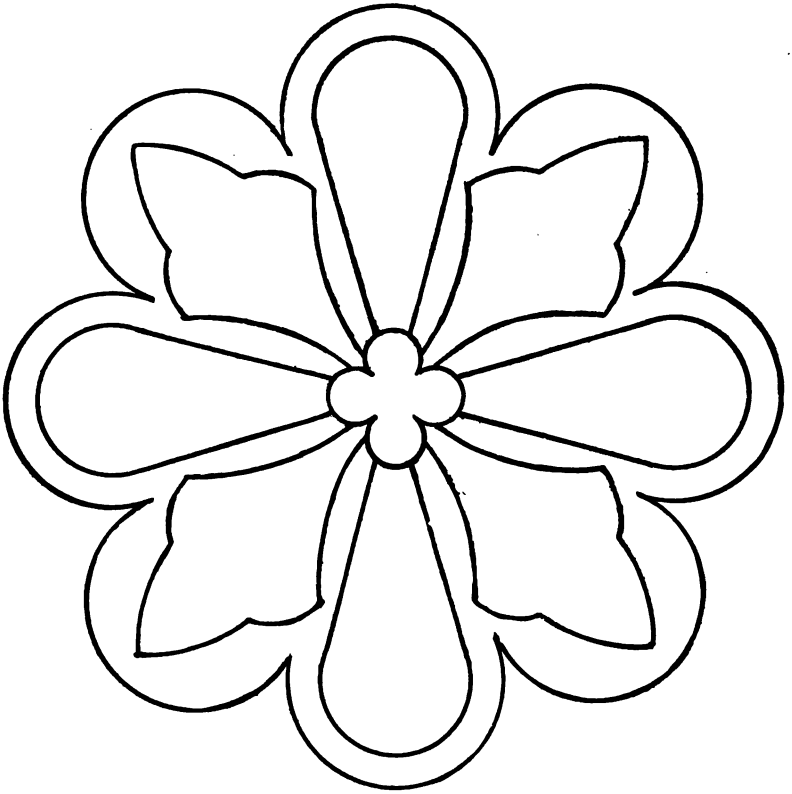


FIG. 18.

draw arcs extending from the middle of one side to the middle of the adjacent side. Draw the diagonals of the octagon. Quadrisect each semi-diagonal. Bisect the distance from the centre to the inner

points of quadrisection. Connect the alternate points of bisection to form a square, on which construct a quatrefoil for the centre figure. A quarter of an inch within one of the arcs described outside the octagon draw a parallel arc, terminating in the sides of the octagon. Connect the ends of the smaller arc with the centre figure by oblique lines. Repeat on the alternate semi-diagonals. In the intervening spaces extend the diagonals to the circumference of the arc. Place a point a quarter of an inch from the end of the line. Bisect each of the parts of the two sides included between the extremities of the arc and connect these points of bisection with the point near the end of the diagonal by lines curving outward from the diagonal. Place points opposite the ends of the arc about a quarter of an inch within the octagon. Connect the points last made on the sides of the octagon with these points by lines curving outward; connect the points within the octagon with the centre by lines curving inward. Repeat in the three remaining spaces.

Erase the octagon, diagonals, and the square in the centre.

Line in the units, centre figure and outline in which the design is placed.

DICTATION (FIG. 19).—Draw a square and its diameters. Extend the vertical diameter above the square the length of a semi-diameter, and the horizontal diameter the same distance to the right. Quadrisect the upper half of the vertical sides of the square and through the upper points draw a horizontal extending beyond the sides of the square a distance equal to about one-eighth of the side of the square. Connect the left end of the horizontal line with the end of the vertical H. L. The end of the extended horizontal diameter is also to be connected with the point H. making the line H. F. These lines indicate the outline of the roof. Divide the upper and lower sides

of the square each into eight equal parts. Sketch very lightly, verticals to connect these points to obtain the position of the door, windows and chimney. Trisect the upper half of the vertical sides, and

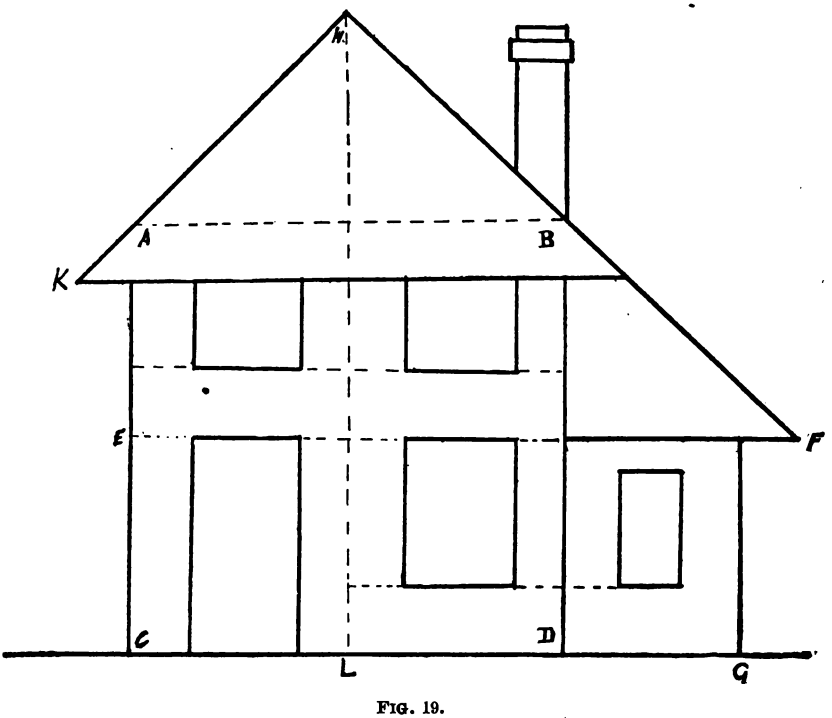


FIG. 19.

draw a horizontal through the lower points of trisection, to obtain the position of the lower edge of upper windows. The top line of the door and lower window is in the diameter of the square, and the

lower edge is found by trisecting the vertical sides of the lower half of the square and drawing a horizontal through the lower point of trisection. The line representing the wall of the "lean-to" is the same distance to the left of the angle F, as the left side of the square is to the right of the angle K. Extend the right side of the square to the height of H. for right side of chimney. — Width one-eighth side of square.

DEFINITIONS.

AXIS — A straight line passing through the centre of an object dividing it into two parts that balance each other.

AXIS OF SYMMETRY — Term used especially in design. A line dividing the figure into two equal parts that are alike in every respect.

ARC — Any part of the circumference of a circle.

ANGLE — The difference in direction.

Angles
- Right — Lines or surfaces perpendicular to each other.
- Acute — When the difference in direction is less than a right angle.
- Obtuse — When the difference in direction is greater than a right angle.

BASE — The line or surface upon which the object rests.

BISECT — To divide into two equal parts.

CIRCLE — A plane figure bounded by a curved line every point of which is equally distant from a point within called the centre.

CIRCUMFERENCE — The curved line which bounds the circle.

CHORD — A straight line connecting the ends of an arc.

CYLINDER — A solid which may be generated by the rotation of a parallelogram round one of its sides.

CUBE — A regular solid having six equal square faces.

CURVILINEAR — Bounded by curved lines.

CURVED LINE — A line no three consecutive points of which lie in the same direction.

CURVE-SUBTILE — A curve the character of which it is difficult to determine.

CURVE-REVERSED — Continuous lines curving in opposite directions.

CURVES-BALANCED — Pairs of curves that bend equally but in opposite directions in every part.

CURVE-SPIRAL — The path of a point revolved about a centre, the distance of the point from the centre constantly increasing.

CURVE-ELLIPTICAL — Having the character of an ellipse.

CURVE-OVOID — Having the character of the oval.

CURVE-CIRCULAR — Having the character of a circle.

DIAMETER — A right line passing through the centre of a figure, connecting the middle of opposite sides.

DIMENSION — Extent in one direction.

DIAGONAL — A straight line connecting opposite angles.

ELLIPSE — A plane figure bounded by a curved line at every point of which the sum of the distances from two points within called foci, is the same.

EDGE — An edge is formed by the contact of two faces.

FACE — Limited part of a surface.

HORIZONTAL — Parallel with the plane of the horizon.

HEIGHT — The vertical measurement. Distance from top to bottom.

LENGTH — Distance from end to end.

LINE — That which has extent in length only.

LINE STRAIGHT — All points lie in the same direction. The shortest path between two points.

MARGIN — The surrounding space or border that is left uncovered by lines or ornament.

OBLONG — A plane figure bounded by four straight lines and having four right angles, with opposite sides equal and parallel.

OBLIQUE — Bending away from the perpendicular.

OUTLINE — Line showing the limit of the visible part of a figure.

OVAL — A figure having the shape of an egg.

PLANE — A surface, any two points of which being taken, the straight line that joins them will lie wholly in the surface.

POINT — The smallest mark that can be made.

PROFILE — The limit of the visible part of round or curved surfaces.

PERPENDICULAR — At right angles to the plane of the horizon.

PRISM — A solid having for its bases or ends any similar polygons, and all of its sides parallelograms.

PARALLEL — Lying in the same direction.

PARALLELOGRAM — A quadrilateral having its opposite sides parallel.

PROPORTION — The adaptation of one part to another, or to the whole.

QUADRISECT — Divide into four equal parts.

QUADRANT — The space inclosed by one-quarter of the circumference, and two radii of a circle.

QUATREFOIL — A figure bounded by equal portions of the circumference of four circles regularly disposed about a common centre.

QUADRILATERAL — A plane figure bounded by four sides.

RADIUS — A straight line from the centre to the circumference of a circle.

RHOMBOID — A quadrilateral, whose opposite sides are equal and parallel, and none of its angles right angles.

RHOMBUS — A quadrilateral having four equal sides and no right angles. An equilateral rhomboid.

RECTILINEAR — Bounded by straight lines.

RECTANGULAR — Having right angles only.

SURFACE — The outside of an object.

SPHERE — A solid bounded by a uniformly curved surface every point of which is equally distant from the centre.

SQUARE — A plane figure bounded by four equal straight lines forming four right angles.

SEMI-CIRCLE — Half a circle.

SEMI-DIAMETER — Half a diameter.

SEMI-DIAGONAL — Half a diagonal.

SECTOR — The space enclosed between any part of the circumference and two radii of a circle.

SECTIONAL VIEW — Shows the object cut by a plane.

TRISECT — To divide into three equal parts.

TRAPEZIUM — A plane figure having four sides no two of which are parallel.

TRAPEZOID — A plane figure having four sides, but only two opposite sides are parallel.

TREFOIL — A figure bounded by equal portions of the circumference of three circles regularly disposed about a centre.

TRIANGLE — A plane figure bounded by three sides.

TRIANGLE EQUILATERAL — A triangle having three equal sides and three equal angles.

TRIANGLE ISOSCELES — A triangle having two equal sides.

TRIANGLE SCALENE — A triangle having no two sides equal.

TRIANGLE RIGHT-ANGLED — A triangle having one right angle.

TRIANGLE OBTUSE-ANGLED — A triangle having one obtuse angle.

TRIANGLE ACUTE-ANGLED — A triangle having all acute angles.

UNIT OF DESIGN — Any form that is repeated to make the design.

VERTICAL — Perpendicular to the plane of the horizon.

WIDTH — Distance from side to side.

WORKING-DRAWING — One from which an object may be constructed.

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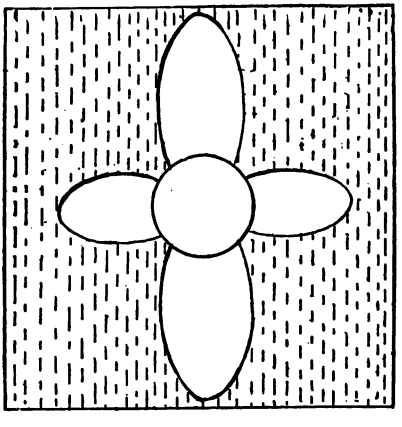

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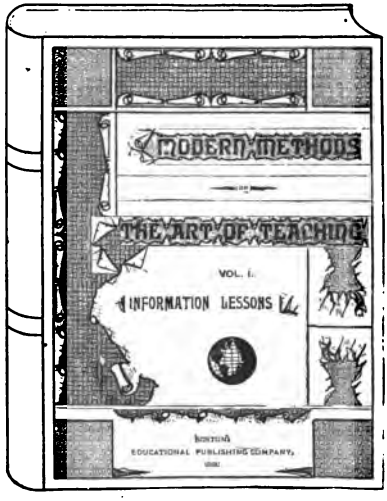

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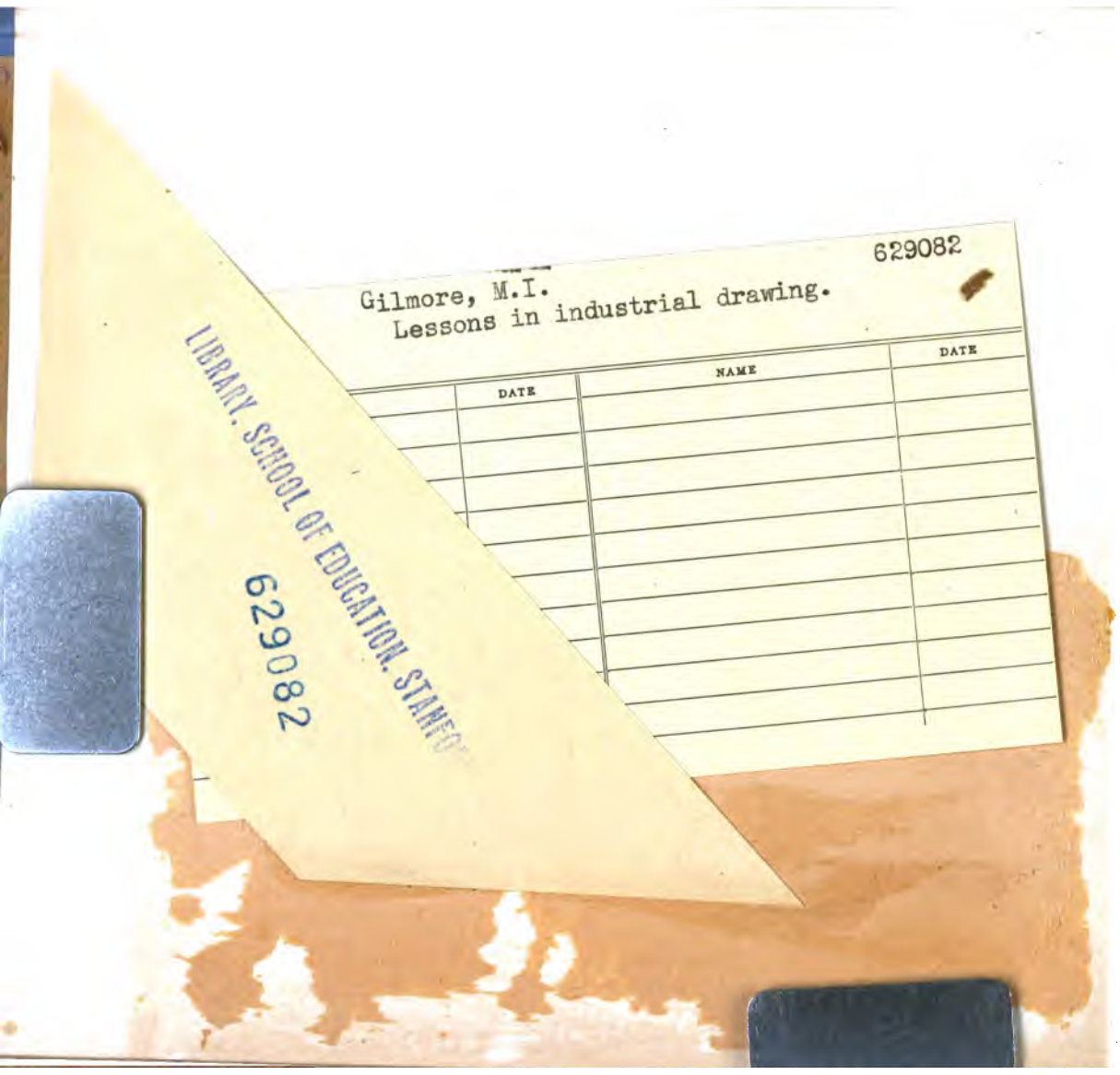
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